APPENDIX A
Quality Assurance Program Plan

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Attachments

ACRONYMS AND ABBREVIATIONS

AED	automated external defibrillator
AOC	Areas of Contamination
BRAC	Base Realignment and Closure
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chain of custody
DL	Detection Limit
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DoD	Department of Defense
DQO	Data Quality Objectives
EB	equipment blank
EDD	electronic data deliverable
FRB	field reagent blank
FSP	Field Sampling Plan
ft bgs	foot below ground surface
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	high-density polyethylene
ID	identifier
IDW	investigative derived waste
KGS	KOMAN Government Solutions, LLC
LCS	laboratory control sample
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
LHA	lifetime health advisory
LOD	Limit of Detection
LOQ	Limit of Quantitation
MassDEP	Massachusetts Department of Environmental Protection
mg/Kg	milligram per kilogram
mg/L	milligram per liter
MPC	Measurement Performance Criteria
MS	matrix spike
MSD	matrix spike duplicate
ng/L	nanogram per liter
NPL	National Priorities List
ORP	oxidation-reduction potential
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PE	Professional Engineer
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PM	Project Manager
QA	quality assurance
QC	quality control

QAPP	quality assurance project plan
QSM	Quality Systems Manual
%R	percent recovery
RI	Remedial Investigation
RPD	relative percent difference
RPM	Remedial Project Manager
RSL	Regional Screening Levels
SDG	sample delivery group
SOP	standard operating procedure
SSSL	Site-specific screening levels
TA	Test America
TOC	Total Organic Carbon
TOP	Total Oxidizable Precursor
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
µg/Kg	micrograms per kilogram

QAPP WORKSHEET #1 AND #2: TITLE AND APPROVAL PAGE

Site Name/Project Name: Former Fort Devens Army Installation (Fort Devens), Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation
Site Location: Devens, Massachusetts
Title: Program Uniform Federal Policy - Quality Assistance Project Plan for Remedial Investigation (RI) of Per- and Polyfluoroalkyl Substances (PFAS) at Fort Devens.
Revision Date: June 2018
Site Names: Areas of Contamination (AOCs) 5, 20, 21, 30, 31, 32/43A, 43G, 43J, 50, 57, 74, 75, and 76; Grove Pond Well Field; and, MacPherson Well.
Contractor Name: KOMAN Government Solutions, LLC (KGS)
Contract Number: W912WJ-18-C-0011
Contract Title: Environmental Services – Former Fort Devens Army Installation BRAC Legacy Sites.

Lead Organization: U.S. Army Corps of Engineers, New England District

Lead Regulatory Program: Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Superfund Amendments and Reauthorization Act of 1986 (SARA), Resource Conservation and Recovery Act (RCRA), and National Contingency Plan (NCP) programs.

Lead Approval Entity: U.S. Environmental Protection Agency.

Plans and reports from previous investigations that are relevant to this QAPP:

KOMAN Government Solutions, LLC (KGS), 2017. *Final Base-Wide Preliminary Assessment for Evaluation of Perfluoroalkyl Substances,* Former Fort Devens Army Installation BRAC Legacy Sites, Devens, Massachusetts. September.

KGS. 2017b. Final Expedited Site Inspection Work Plan for Per- and Polyfluoroalkyl Substances (PFAS), Former Fort Devens Army Installation Devens, MA. May 2017.

KGS. 2018a. Addendum to the Expedited Site Inspection Work Plan for Per- and Polyfluoroalkyl Substances (PFAS), Former Fort Devens Army Installation Devens, MA. September 2018.

KGS, 2018b. Additional PFAS Sampling to Support the Development of the Remedial Investigation Work Plan, Former Fort Devens Army Installation, Devens, MA. Prepared for the US Army Corps of Engineers New England District. April 2018. KGS, 2017 Final

BERS-Weston Services, JVA, LLC (BERS-Weston), 2018a. *Final Site Inspection Report for Per- and Polyfluoroalkyl Substances (PFAS) at Former Fort Devens Army Installation, Devens, MA.* June.

BERS-Weston, 2018b. *Draft Site Inspection Report for Per- and Polyfluoroalkyl Substances (PFAS) at Area of Contamination (AOC) 76 – Devens Fire Department, Former Fort Devens Army Installation, Devens, MA.* April.

Organizational partners (stakeholders) and connection with lead organization:

US EPA Region I,
Massachusetts Department for Environmental Protection (MassDEP),
MassDevelopment,
Restoration Advisory Board, and
Base Realignment and Closure (BRAC) Team

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Penelope Reddy
Contracting Officer's Representative/ Project Manager
U.S. Army Corps of Engineers, New England District

Yixian Zhang
Project Chemist
U.S. Army Corps of Engineers, New England District

Mark Applebee, P.E.
Program Manager
KOMAN Government Solutions, LLC

James Ropp, P.E.
Project Manager
KOMAN Government Solutions, LLC

Laurie Ekes
Project Chemist
KOMAN Government Solutions, LLC

QAPP WORKSHEET #3: DISTRIBUTION LIST FOR DEVENS

QAPP Recipients	Title	Organization	E-mail Address
Mark Applebee	Program Manager	KGS	mapplebee@komangs.com
James Ropp	Project Manager (PM)	KGS	jropp@komangs.com
John Rawlings	Corporate Director of Safety and Quality Control	KOMAN	jrawlings@komaninc.com
Katherine Thomas	Technical Lead	KGS	kthomas@komangs.com
Kevin Anderson	KGS Field Team Lead	KGS	kanderson@komangs.com
Laurie Ekes	Project Chemist	KGS	lekes@komangs.com
Denise Tripp	Hydrogeologist	Geosyntec	Dtripp@geosyntec.com
Spence Smith	PM	Jacobs	Spence.Smith@jacobs.com
Jerry Lanier	PM	Test America Savannah	Jerry.lanier@testamericainc.com
Penelope Reddy	PM	USACE	Penelope.Reddy@usace.army.mil
Yixian Zhang	Project Chemist	USACE	Yixian.Zhang@usace.army.mil
Robert Simeone	BRAC Environmental Coordinator	US Army	robert.j.simeone.civ@mail.mil
Carol Keating	Remedial PM	USEPA Region I	Keating.Carol@epa.gov
David Chaffin	Federal Sites Program	MassDEP	David.Chaffin@state.ma.us

QAPP WORKSHEET #4, 7 & 8: PERSONNEL TRAINING, RESPONSIBILITIES AND SIGN-OFF SHEET

ORGANIZATION: KGS

Name	Project Title	Specialized Training/Certifications	Responsibilities	Signature/Date
Mark Applebee	Program Manager	Project Management Professional (PMP), Hazardous Waste Operations and Emergency Response (HAZWOPER) 40-hour Training; 8-Hour Refresher; CPR and first aid/AED	Oversight responsibility for contractual and technical performance.	
James Ropp	Project Manager	Licensed Professional Engineer (PE), HAZWOPER 40-hour Training; 8-Hour Refresher; CPR and first aid/AED	Manages project technical and contractual requirements; coordinates between senior management, USACE, stakeholders, and project staff.	
Katherine Thomas	Technical Lead	PMP, HAZWOPER 40-hour Training; 8-Hour Refresher; CPR and first aid/AED	Manages remedial investigation technical task requirements; supports coordination at all levels.	
Kevin Anderson	Field Team Leader	HAZWOPER 40-hour Training; 8-Hour Refresher; CPR and first aid/AED	Supervises field sampling and coordinates all field activities; serves as the site KGS coordinator.	
Laurie Ekes	Project Chemist	HAZWOPER 40-hour Training; 8-Hour Refresher; CPR and first aid/AED	Verifies that the UFP-QAPP analytical requirements are met by the laboratory and field staff. Also provides direction regarding requirements for corrective actions for field and analytical issues; evaluates and releases validated analytical results to the KGS project team.	

QAPP WORKSHEET #4, 7 AND 8 - Continued

ORGANIZATION: Army/USACE

Name	Project Title	Specialized Training/Certifications	Responsibilities	Signature/Date
Robert Simeone	BRAC Environmental Coordinator		BRAC Environmental Coordinator for Devens Environmental Remediation.	
Penelope Reddy	Technical Lead		USACE PM for Devens Environmental Remediation	
Yixian Zhang	Project Chemist	HAZWOPER 40-hour Training; 8-Hour Refresher	Coordinates with KGS project chemist. Reviews field activities and laboratory data.	

ORGANIZATION: Test America, Savannah

Name	Project Title	Specialized Training/Certifications	Responsibilities	Signature/Date
Jerry Lanier	Project Manager	Not applicable	Primary point of contact for Test America Laboratory. Receives direction from KGS Project Chemist. Responsible for ensuring the UFP-QAPP requirements are met by the laboratory.	

ORGANIZATION: Test America, Sacramento

Name	Project Title	Specialized Training/Certifications	Responsibilities	Signature/Date
Debby Wilson	Client Services Manager (PFAS)	Not applicable	Manages client services for TestAmerica Laboratories, Sacramento.	

QAPP WORKSHEET #4, 7 AND 8 - Continued

ORGANIZATION: Alpha Analytical

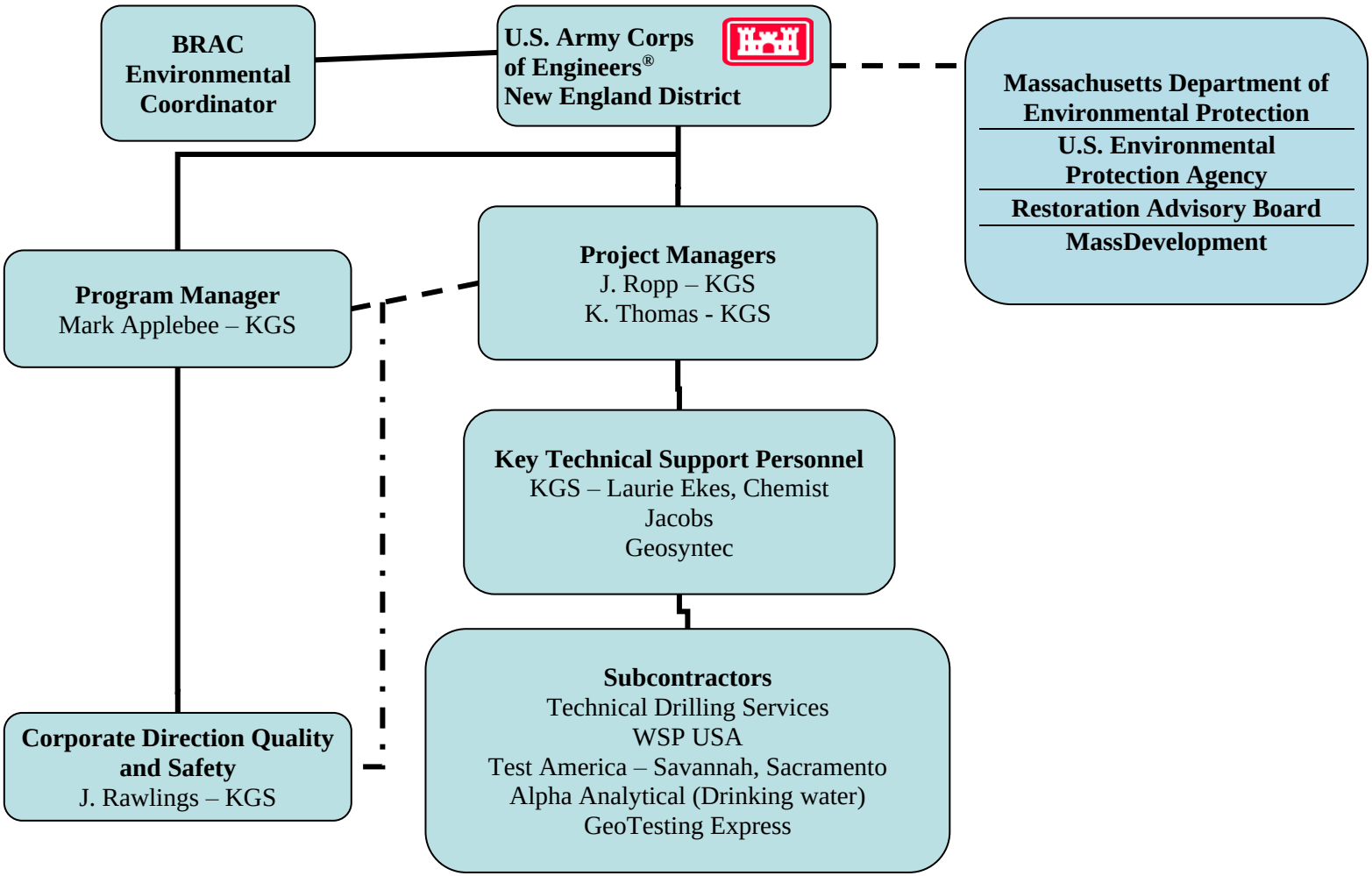
Name	Project Title	Specialized Training/Certifications	Responsibilities	Signature/Date
Jim Occhialini		Not applicable	Manages client services for Alpha Analytical.	

ORGANIZATION: GeoTesting Express

Name	Project Title	Specialized Training/Certifications	Responsibilities	Signature/Date
Mark Dobday	Laboratory Manager	Not applicable	Primary point of contact for GeoTesting Express. Receives direction from KGS Project Chemist. Responsible for ensuring the UFP-QAPP requirements are met by the laboratory for grain size analysis.	

Signatures indicate personnel have read and agree to implement this QAPP as written

QAPP WORKSHEET #5: PROJECT ORGANIZATIONAL CHART



QAPP WORKSHEET #6: COMMUNICATION PATHWAYS

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Communication with USACE (lead agency)	USACE Program Manager	Penelope Reddy	(978) 318-8160	Primary point of contact with USACE. Coordinates contracting actions. Provides direction to KGS.
Communication with BRAC	BRAC EC	Robert Simeone	(978) 796-2205	Primary point of contact for Fort Devens.
Communication with EPA	EPA RPM	Carol Keating	(617) 918-1393	Primary point of contact for EPA. Provides technical and regulatory input and recommendations to USACE.
Communication with MassDEP	MassDEP RPM	David Chaffin	(617) 348-4005	Primary point of contact for MassDEP. Provides technical and regulatory input and recommendations.
Communication with KGS	KGS PM	James Ropp	(603) 395-7986	Primary point of contact for KGS. Provides project management input and recommendation to USACE PM. Receives direction from USACE.
Secondary point of contact for KGS	KGS Technical Lead	Katherine Thomas	(774) 273-1467	Primary point of contact for technical tasks; provides technical input and recommendations to UACE. Receives technical direction from USACE; provides input to KGS PM and project team on project status.
Progress of field program	KGS	Kevin Anderson	(508) 366-7442	Conveys progress of field activities. Communication with KGS technical lead. Oversees onsite safety activities.
Communication with KGS Project Chemist	Test America (TA) Savannah Laboratory Project Manager	Jerry Lanier	(912) 354-7858	Coordinates laboratory staff to assure timely deliverables. Communicates QA/QC issues with project chemist. Approves release of analytical data from laboratory.
	TA Sacramento Laboratory Project Manager	Debby Wilson	(949) 260-3228	
	Alpha Analytical	Jim Occhialini	(508) 898-9220	PFAS drinking water sample laboratory coordination.
	GeoTesting Express Laboratory manager	Mark Dobday	(978) 635-0424	Coordinates lab staff and approves release of grain size analysis

QAPP Worksheet #6 - Continued

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Review and release of analytical data	KGS Project Chemist	Laurie Ekes	(508) 366-7442	Verifies the UFP_QAPP analytical requirements are met by the laboratory and field staff. Coordinates sampling activities with analytical laboratory. Evaluates and releases analytical results to the KGS PM.

QAPP WORKSHEET #9: PROJECT SCOPING SESSION PARTICIPANTS SHEET

Project Name: Devens PFAS Remedial Investigation **Projected Date(s) of Sampling:** September 2018 **Project Manager:** James Ropp	**Site Name:** Former Fort Devens Army Installation (RI site-specific areas include: AOCs 5, 20, 21, 30, 31, 32/43A, 43G, 43J, 50, 57, 74, 75, 76; Grove Pond Well Field; and MacPherson Supply Well). **Site Locations:** Devens, MA

Date of Session: April 25, 2018

Scoping Session Purpose: To discuss draft data quality objectives that was circulated to the team before the meeting.

Attendees:

Bob Simeone (Army BRAC)	Mark Wetzel (Town of Ayer)
Penny Reddy (USACE)	Greg Kemp (Mabbett)
Mike Kulbersh (USACE)	Ron Ostrowski (MassDevelopment)
Dan Groher (USACE)	Julie Corenzwit (PACE)
Carol Keating (EPA)	Rich Doherty (PACE)
Laurie O'Connor (EPA)	Mark Applebee (KGS)
Bill Brandon (EPA)	Katie Thomas (KGS)
Jim Murphy (EPA)	Spence Smith (Jacobs) via Phone
Zanetta Purnell (EPA	Mark Hilyard (Jacobs) via Phone
Dave Chaffin (MassDEP)	

Date of Session: May 24, 2018, meeting minutes in Attachment D

Scoping Session Purpose: To discuss details from the draft Area 1 Field Sampling Plan that was circulated to the team before the meeting.

Attendees:

Bob Simeone (Army BRAC)	Mark Wetzel (Town of Ayer)
Penny Reddy (USACE)	Rich Doherty (PACE)
Mike Kulbersh (USACE)	Mark Applebee (KGS)
Dan Groher (USACE)	Jim Ropp (KGS)
Carol Keating (EPA)	Katie Thomas (KGS)
Laurie O'Connor (EPA)	Spence Smith (Jacobs)
Greg Kemp (Mabbett)	Mark Hilyard (Jacobs)
Dave Chaffin (MassDEP)	

QAPP WORKSHEET #10 CONCEPTUAL SITE MODEL

The conceptual site model of PFAS at Fort Devens is presented in Section 3.0 of the RI Work Plan for PFAS.

QAPP WORKSHEET #11: DATA QUALITY OBJECTIVES

Step 1: State the Problem

PFAS have been detected in groundwater, surface water, soil, and sediment at multiple Fort Devens AOCs at concentrations that may impact human health and the environment.

Step 2: Identify the Study Goals, Questions and Decision Statements

Study Goals

Site characterization data are needed to define the nature and extent of PFAS at Fort Devens and downgradient of Fort Devens in groundwater and determine migration flow paths to evaluate current and potential impacts to public and private drinking water supply wells and surface water discharge areas.

Site characterization data are needed to identify sources of PFAS in soil at Fort Devens, either currently known sources or newly identified potential sources determined through the investigation, contributing to PFAS in groundwater and characterize the nature and extent of those sources including evaluation of sources in soil as potential continuing sources.

Additional data are also needed to support a quantitative human health risk assessment and an ecological risk evaluation, which will be completed to estimate potential human health and ecological risk from exposure to PFAS in groundwater, soil, surface water, and sediment.

Principle Study Questions and Associated Decision Statements:

- Are the PFAS detected at AOCs 32/43, 57, 74, and 75 impacting the Grove Pond water supply wells?
    - Decision Statement: Determine nature and extent of PFAS in groundwater impacting the Grove Pond water supply wells, nature and extent of PFAS in groundwater attributable to each AOC, hydraulic characteristics of the aquifer, groundwater flow directions, fate and transport of PFAS in the aquifer, and evaluate PFAS distribution using lines of evidence including ratios of select PFAS compounds.
- Are the PFAS detected in groundwater at AOCs 5, 20, 21, 32/43, and 76, impacting the MacPherson supply well?
    - Decision Statement: Determine nature and extent of PFAS in groundwater impacting the MacPherson supply well, nature and extent of PFAS in groundwater attributable to each AOC, hydraulic characteristics of the aquifer, groundwater flow directions, fate and transport of PFAS in the aquifer, evaluate PFAS distribution using lines of evidence including ratios of select PFAS compounds.
- What is the predicted impact of AOCs to water supply wells over time?
    - Decision Statement: Determine nature and extent of PFAS in groundwater attributable to each AOC, hydraulic characteristics of the aquifer, groundwater flow directions, fate and transport of PFAS in the aquifer to estimate velocity of contaminant transport and travel times), nature and extent of PFAS in soil, fate and

transport of PFAS from soil to groundwater, nature and extent of precursors in soil and groundwater, and evaluate potential for precursors to transform.

- Do other sources of PFAS exist that impact the Grove Pond and MacPherson supply wells?
    - Decision Statement: Determine nature and extent of PFAS in groundwater impacting the Grove Pond and MacPherson water supply wells, groundwater flow directions, evaluate PFAS distribution using lines of evidence including ratios of select PFAS compounds.
- Are there any other water supply wells that are potentially impacted by PFAS originating from Fort Devens?
    - Decision Statement: Determine nature and extent of PFAS associated with the AOCs, hydraulic characteristics of the aquifer, groundwater flow directions, fate and transport of PFAS in the aquifer, identify other water supply wells and associated construction information through research of appropriate public records and interviews, and sampling of other water supply wells, if appropriate.
- Are the PFAS detected in groundwater attributable to identified AOC source areas?
    - Decision Statement: Determine if PFAS in groundwater exists up gradient or cross gradient of the AOC source, hydraulic characteristics of the aquifer, groundwater flow directions, fate and transport of PFAS in the aquifer, and evaluate PFAS distribution using lines of evidence including ratios of select PFAS compounds.
- Are the PFAS detected in groundwater discharging to surface water bodies at concentrations that may pose a risk to human health and the environment?
    - Decision Statement: Determine PFAS concentrations in surface water and sediment where groundwater contaminated with PFAS is anticipated to discharge, human health and ecological risk from PFAS in surface water and sediment, hydraulic flow paths from the groundwater to the surface water, hydraulic characteristics of the aquifer, fate and transport of PFAS in the aquifer, and PFAS concentrations in groundwater discharging to surface water bodies.
- Are the PFAS detected in soil at concentration that may pose a risk to human health?
    - Decision Statement: Determine nature and extent of PFAS in soil and determine the human health risk from exposure to soil.
- Do PFAS concentrations in groundwater pose an unacceptable risk to human health?
    - Decision Statement: Determine nature and extent of PFAS in groundwater and human health risk from exposure to groundwater.
- Do PFAS concentrations in soil represent a significant continuing source impacting groundwater at concentrations that pose an unacceptable human health risk?
    - Decision Statement: Determine nature and extent of PFAS in soil, fate and transport of PFAS in soil to groundwater, nature and extent of PFAS concentrations in groundwater, hydraulic characteristics of the aquifer, groundwater flow direction,

fate and transport of PFAS in the aquifer, point of human exposure to groundwater, and human health risk via a complete exposure pathway.

Step 3: Identify Information Inputs

Information inputs include historical data gathered on the sites and analytical data collected during the investigation. PFAS concentrations in water samples collected from existing and new monitoring wells, vertical profile borings, and private and public water supply wells used for drinking water. PFAS concentrations in soil samples collected from the ground surface and soil borings. PFAS concentrations in surface water and sediment samples collected from potentially impacted water bodies. Organic carbon in soil and water collected from soil borings and existing and new monitoring wells. Inputs include the site-specific screening levels and detection level objectives as defined in Worksheet #15.

Grain size analysis of soil and sediment samples. Lithologic characterization of aquifer materials. Hydraulic conductivity test after installation of monitoring wells at select locations. Groundwater level measurements after installation of monitoring wells and/or piezometers. An inventory of water supply wells.

Step 4: Define the Boundaries of the Study

Each Area-specific Field Sampling Plan (FSP) addenda specifies drilling and sampling locations. Additional drilling and/or sampling locations may be added to the investigation based on initial investigation results and area-specific objectives.

Step 5: Develop the Analytic Approach

If data from this investigation are sufficient to adequately characterize the nature and extent of PFAS in groundwater, to determine all PFAS migration pathways, to assess the fate and transport of PFAS, to assess water supply impacts, and to adequately assess human health risk then additional data will not be collected. EPA Lifetime Health Advisories (LHA), site-specific screening levels (SSSL), EPA Regional Screening Levels (RSL), and/or appropriate MassDEP guidance will be used for comparison purposes to assess the adequacy of the data. If significant data gaps are identified, then further data will be collected.

If data from this investigation are sufficient to adequately characterize the nature and extent of PFAS in soils, surface water, and sediment and to adequately assess human health risk and conduct an ecological risk evaluation, then additional data will not be collected. If significant data gaps are identified, then further data will be collected.

Soil and groundwater containing PFAS at concentrations greater than EPA LHA, SSSLs, and/or EPA RSLs, will be evaluated for potential risk to human health. If no unacceptable risk is identified, then no further action will be recommended for soil and/or groundwater. If a CERCLA human health risk assessment indicates unacceptable risk to human health, then a feasibility study will be conducted.

Surface water and sediment containing PFAS, will be evaluated for potential risk to human health. If no unacceptable risk is identified, then no further action will be recommended for surface water and/or sediment. If a CERCLA human health risk assessment indicates unacceptable risk to human health, then a feasibility study will be conducted.

If a complete exposure pathway for ecological receptors to PFAS, is identified, then a qualitative ecological risk evaluation will be completed. PFAS data will be compared to latest ecotoxicology values presented in scientific literature and in accordance with Army Guidance (Department of the Army, 2018). If an unacceptable risk to ecological risk is identified, further evaluation will be conducted.

Step 6: Specify Performance or Acceptance Criteria

Analytical data performance criteria/data quality indicators are specified in QAPP Worksheet #12. These data quality indicators include indicators (performance criteria) for precision, accuracy/bias, sensitivity, and completeness. To determine whether the detection limits (DL), limits of detection (LOD), and limits of quantitation (LOQ) will meet the analytical DQOs, the DLs, LODs, and LOQs have been compared to the project-specific screening criteria in Worksheet #15. With respect to data verification, validation, and usability: QAPP Worksheet #34 provides Data Verification and Validation Inputs; QAPP Worksheet #35 provides Data Verification Procedures; QAPP Worksheet #36 provides Data Validation Procedures; and QAPP Worksheet #37 provides Data Usability Assessment.

Step 7: Develop the Detailed Plan for Obtaining Data

The sampling design and rationale was developed for each area of investigation and is presented in each Area-specific FSP Addendum.

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA

Measurement performance criteria (MPC) have been established for the analytical parameters for this project. The required MPCs for each analytical parameter are presented in the following Worksheets:

- Worksheet #15 – "Project Action Limits, Method Reporting Limits and Control Limits" for Project Action Limits and reporting limit objectives
- Worksheet #24 – "Analytical Instrument Calibration" for respective instrument calibration requirements.
- Worksheet #28 – "Analytical Quality Control and Corrective Actions" for the requirements of laboratory QA/QC activities.
- Worksheets #34, 35 and 36 – "Data Verification and Validation Inputs and Procedures" for data review and validation process.

The quality of the data to be collected for the project will be verified using appropriate MPC established for both sampling procedures and analytical methods. The criteria will relate to the specific area target compounds lists and reporting limit objectives. The MPCs follow those defined in the DoD Quality Systems Manual (QSM) Version 5.1 (DoD, 2017). The sampling procedures and the quality of the laboratory results will be evaluated for compliance with project-specific DQOs through a review of overall precision, accuracy, representativeness, comparability, completeness and sensitivity (PARCCS) in accordance with procedures described in Worksheet #37 (Data Usability Assessment).

QAPP WORKSHEET #13: SECONDARY DATA CRITERIA AND LIMITATIONS TABLE

Secondary Data	Data Source	Types of Data Used	Reliability and Limitations on Data Use
Historical Summary of AOCs	*Final Base-Wide Preliminary Assessment for Evaluation of Perfluoroalkyl Substances*, Former Fort Devens Army Installation BRAC Legacy Sites, Devens, Massachusetts. KOMAN Government Solutions, LLC, September 2017.	Historical description of land use and ownership and identified waste streams	No limitations.
Contaminant of Concern Data	*Final Site Inspection Report for Per- and Polyfluoroalkyl Substances (PFAS) at Former Fort Devens Army Installation, Devens, MA.* BERS-Weston Services, JVA, LLC, May 2018.	Operational and waste characteristics; groundwater use; soil, groundwater; surface water and sediment sampling data	None, except as identified for individual data points in the associated data quality evaluation.
Contaminant of Concern Data	Additional PFAS Sampling to Support the Development of the Remedial Investigation Work Plan. KGS, 2018.	Groundwater and surface water sampling data at site-specific AOCs	None, except as identified for individual data points in the associated data quality evaluation.
Meteorological Data	National Weather Service	Seasonal precipitation rates and fluctuations in storm water runoff	Published data are available for past 20 years. No known limitations
Topographical Data	U.S. Geological Survey	Surface water and overland drainage pathway	Man-made alterations to topographic surface such as regrading and landfill appointment
Other contaminant data, Geology Data, Hydrogeology Data	Multiple reports	Approximately 30 years of data collection at sites across Fort Devens.	No limitations.

QAPP WORKSHEETS 14 & #16: PROJECT TASKS AND SCHEDULE

Schedule: The field activities will commence after concurrence on each Area-specific field sampling plan addendum has been received.
Pre-Sampling Activities: The pre-sampling activities will include coordinating site access, acquiring subcontractors and materials, and coordination of field staff.
Sampling Activities: Sampling tasks are detailed, for each site in the appropriate Area-specific FSP Addendum.
Analysis Tasks: *Laboratory analyses* – Laboratory analyses for the potential sampling activities included in this QAPP are listed in Worksheets #15. *Field analyses* –Groundwater samples will be collected from monitoring wells following the low flow sampling procedure. Water quality parameters will be measured for each well at 5-minute intervals, until stabilization and immediately prior to sampling. These parameters include: pH, turbidity, conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), and temperature.
Quality Control Tasks: Field QC samples will be collected at the frequency specified in Worksheet #20. Laboratory QC samples are specified in Worksheet #28. Laboratory QC tasks are defined in laboratory SOPs (Attachment B) and are summarized in Worksheets #24.
Secondary Data: See Worksheet #13.
Documentation and Records: Field observations and sampling records will be entered onto field sheets. Chain of custody (CoC) forms, investigation records, well stabilization parameter logs, field instrument calibration logs, and investigation-derived waste records will be prepared and retained in project files.
Analytical Data Reports: Analytical data packages will be required to contain all data required to perform data review in accordance with Stage 2B data validation protocols as defined by *General Data Validation Guidelines,* (DoD Environmental Data Quality Workshop, February 9, 2018). Sufficient documentation will be provided by the laboratory to allow for calibration, QC, blank, and other relevant information to be related to each of the associated sample analyses. Project completeness will be evaluated during data verification. Data verification and validation criteria are summarized in Worksheets #34, 35, and 36.
Assessment/Audit Tasks: The laboratory's certification status and compliance with DoD QSM 5.1 were reviewed prior to contract award. The laboratory's precision, accuracy, completeness, and sensitivity performance were reviewed and are comparable to or better than the project requirements.

QAPP Worksheets #14 & 16 – Continued

Data Review Tasks:

Data verification is a completeness check to confirm that the required activities were conducted as planned and field and laboratory records are present and complete. Data validation is an assessment of the performance associated with the laboratory analysis in order to determine the quality of the data, which will be accomplished by evaluating whether the collected data comply with the project requirements. The collected data will be compared with criteria established based on the project DQOs as defined in Worksheet #11. Data verification and validation tasks are detailed in Worksheets #34, 35 and 36.

Data Usability:

Data usability is an evaluation based on the results of data verification and validation in the context of the overall project decisions or objectives. The assessment is used to determine whether the project execution and resulting data meet the project DQOs. Both the sampling and analytical activities must be evaluated, with the ultimate goal of assessing whether the final, qualified results support the decisions to be made with the data. Data usability assessment is detailed in Worksheet #37.

Reporting:

The PFAS sample results will be presented to the regulatory agencies following receipt of results and following receipt of validated results. The data will be presented in the RI report.

QAPP WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLE

One of the primary goals of the project-specific UFP-QAPP is to select appropriate analytical methods to achieve detection limits (DL), limits of detection (LOD), and/or limits of quantitation (LOQ) that will satisfy the overall project DQOs (as defined in Worksheets # 10 [Conceptual Site Model] and #11 [Data Quality Objectives]).

Groundwater and soil samples will be collected and submitted for PFAS analysis by "modified" method 537 (LC/MS/MS isotope dilution) compliant with QSM 5.1, Table B-15. Groundwater and soil samples from select locations will be processed by the laboratory through a total oxidizable precursor (TOP) assay. The TOP assay converts polyfluorinated precursors into fully fluorinated compounds (PFOS and PFOA) using a hydroxyl radical-based chemical oxidation method. The TOP assay replicates what micro-organisms in the environment would achieve after many years. Aqueous and soil samples that are oxidized via the TOP assay will have two sets of sample data reported, which will be designated pre-TOP and Post-TOP. The difference between PFAS concentrations before (Pre-TOP) and after (Post-TOP) oxidation can be used to estimate the concentration of the non-discrete oxidizable precursors in the sample. Select samples will also be submitted for organic carbon analysis, total organic carbon (TOC) for soil samples and dissolved organic carbon (DOC) for aqueous samples.

Worksheets #15-1a and #15-1b list the analytical method DLs, LODs, and LOQs for the target PFAS in aqueous samples and worksheets #15-2a and #15-2b list the analytical method DLs, LODs, and LOQs for the target PFAS in solid samples. Worksheets #15-1b and #15-2b list the respective DLs, LODs, and LOQs for post-TOP aqueous and soil samples. Slightly higher DLs, LODs and LOQs are reported for post-TOP samples due to the limited sample volume processed through the TOP assay.

Worksheets #15-1 and #15-2 show the LHA levels and SSSLs for PFAS with respect to the current analytical DL, LOD, and LOQ for each listed target compound. In all cases the expected detection levels are below the applicable LHAs, SSSLs and soil standards. If the LOD or the DL is below the screening criterion, the LOD and/or the LOQ are sufficient for quantitative use in a risk assessment.

Note that sample dilution because of target and or non-target compound concentrations or matrix interference may prevent DLs, LODs, or LOQs from being achieved. The samples must be initially analyzed undiluted when reasonable. If a dilution is necessary, both the original and diluted result must be delivered. Samples that are not analyzed undiluted must be supported by matrix interference documentation such as sample viscosity, color, odor, or results from other analyses of the same sample to show that an undiluted sample is not possible.

Worksheet #15-3 lists the analytical method DLs, LODs, and LOQs for target PFAS in drinking water samples, which will be analyzed by the drinking water method 537 Revision1.1.

Worksheet #15-4 lists the DLs, LODs, or LOQs for DOC in aqueous samples and TOC in soil.

QAPP WORKSHEET #15-1A: ANALYTICAL METHOD REPORTING LIMITS AND CONTROL LIMITS

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit (ng/L)	Project Action Limit Reference[2]	LOQ (ng/L)	LOD (ng/L)	DL (ng/L)	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
Groundwater/Surface Water	2058-94-8	Perfluoroundecanoic acid (PFUnA)	NA	--	2.00	1.50	0.72	76	105	30
Direct Analysis/Pre-TOP Assay	375-73-5	Perfluorobutanesulfonic acid (PFBS)	40,100	EPA	2.00	1.00	0.46	87	120	30
PFAS Analysis by LC/MS/MS	335-76-2	Perfluorodecanoic acid (PFDA)	NA	--	2.00	1.00	0.48	85	113	30
Isotope Dilution Method	307-55-1	Perfluorododecanoic acid (PFDoA)	NA	--	2.00	1.50	0.52	87	116	30
	375-85-9	Perfluoroheptanoic acid (PFHpA)	NA	--	2.00	1.50	0.61	80	113	30
	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	NA	--	2.00	1.00	0.38	81	106	30
	307-24-4	Perfluorohexanoic acid (PFHxA)	NA	--	2.00	1.00	0.47	83	109	30
	375-95-1	Perfluorononanoic acid (PFNA)	NA	--	2.00	1.50	0.52	83	113	30
	1763-23-1	Perfluorooctanesulfonic acid (PFOS)	70/40.1	LHA/EPA	4.00	3.00	1.10	82	112	30
	335-67-1	Perfluorooctanoic acid (PFOA)	70/40.1	LHA/EPA	2.00	1.50	0.54	80	107	30
	72629-94-8	Perfluorotridecanoic Acid (PFTriA)	NA	--	4.00	3.00	0.76	75	129	30
	376-06-7	Perfluorotetradecanoic acid (PFTeA)	NA	--	4.00	3.00	0.83	82	115	30
	2991-50-6	N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	NA	--	20.0	10.0	2.80	80	109	30
	2355-31-9	N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	NA	--	20.0	10.0	3.00	82	111	30
	27619-97-2	1H, 1H, 2H, 2H-perfluorooctane sulfonate (6:2 FTS)	NA	--	40.0	20.0	7.00	75	118	30
	39108-34-4	1H, 1H, 2H, 2H-perfluoroecane sulfonate (8:2 FTS)	NA	--	20.0	10.0	3.00	83	111	30

Source: Test America Sacramento - March 25, 2018

[1] See Worksheet #23 for Analytical SOP References

[2] LHA - Federal Register; Vol.81 #101, May 2016

EPA - Region 1 Memorandum: Site-Specific Screening Levels for PFOA, PFOS, and PFBS for the Fort Devens NPL Site, 2/28/18.

QAPP Worksheet #15-1A - Continued

Notes:

NA = not available
PFAS = per- and polyfluoroalkyl substances
CAS = Chemical Abstract Service
LOQ = limit of quantitation
LOD = limit of detection
LCS = laboratory control sample
DL = detection limit
MS = Matrix Spike
MSD = matrix spike
ng/L = nanogram per liter
RPD = relative percent difference

QAPP WORKSHEET #15-1B: ANALYTICAL METHOD REPORTING LIMITS AND CONTROL LIMITS

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit (ng/L)	Project Action Limit Reference[2]	LOQ (ng/L)	LOD (ng/L)	DL (ng/L)	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
Groundwater/Surface Water	2058-94-8	Perfluoroundecanoic acid (PFUnA)	NA	--	5.00	3.75	2.80	57	117	30
Post-TOP Assay	375-73-5	Perfluorobutanesulfonic acid (PFBS)	40,100	EPA	5.00	2.50	0.50	75	135	30
PFAS Analysis by LC/MS/MS	335-76-2	Perfluorodecanoic acid (PFDA)	NA	--	5.00	2.50	0.78	65	125	30
Isotope Dilution Method	307-55-1	Perfluorododecanoic acid (PFDoA)	NA	--	5.00	3.75	1.40	66	126	30
	375-85-9	Perfluoroheptanoic acid (PFHpA)	NA	--	5.00	3.75	0.63	104	171	30
	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	NA	--	5.00	2.50	0.43	64	124	30
	307-24-4	Perfluorohexanoic acid (PFHxA)	NA	--	5.00	2.50	1.40	81	141	30
	375-95-1	Perfluorononanoic acid (PFNA)	NA	--	5.00	3.75	0.68	66	126	30
	1763-23-1	Perfluorooctanesulfonic acid (PFOS)	70/40.1	LHA/EPA	5.00	3.00	0.80	68	128	30
	335-67-1	Perfluorooctanoic acid (PFOA)	70/40.1	LHA/EPA	5.00	3.75	2.10	158	454	30
	72629-94-8	Perfluorotridecanoic Acid (PFTriA)	NA	--	5.00	3.50	3.20	65	136	30
	376-06-7	Perfluorotetradecanoic acid (PFTeA)	NA	--	5.00	3.00	0.73	63	123	30
	2991-50-6	N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	NA	--	50.0	12.5	7.80	0	10	30
	2355-31-9	N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	NA	--	50.0	12.5	4.80	0	10	30
	27619-97-2	1H, 1H, 2H, 2H-perfluorooctane sulfonate (6:2 FTS)	NA	--	50.0	12.5	5.00	0	10	30
	39108-34-4	1H, 1H, 2H, 2H-perfluoroecane sulfonate (8:2 FTS)	NA	--	50.0	12.5	5.00	0	10	30

Source: Test America Sacramento - March 25, 2018

[1] See Worksheet #23 for Analytical SOP References

[2] LHA - Federal Register; Vol.81 #101, May 2016

EPA - Region 1 Memorandum: Site-Specific Screening Levels for PFOA, PFOS, and PFBS for the Fort Devens NPL Site, 2/28/18.

Notes:

NA = not available
PFAS = per- and polyfluoroalkyl substances
CAS = Chemical Abstract Service
LOQ = limit of quantitation
LOD = limit of detection
LCS = laboratory control sample
DL = detection limit
MS = Matrix Spike
MSD = matrix spike
ng/L = nanogram per liter
RPD = relative percent difference

QAPP WORKSHEET #15-2A: ANALYTICAL METHOD REPORTING LIMITS AND CONTROL LIMITS

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit (µg/Kg)	Project Action Limit Reference[2]	LOQ (µg/Kg)	LOD (µg/Kg)	DL (µg/Kg)	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
Soil/Sediment	2058-94-8	Perfluoroundecanoic acid (PFUnA)	NA	--	0.300	0.200	0.100	74	114	30
Direct Analysis/Pre-TOP Assay	375-73-5	Perfluorobutanesulfonic acid (PFBS)	126,000/ 609,000	EPA Soil/Sediment	0.400	0.180	0.059	73	142	30
PFAS Analysis by LC/MS/MS	335-76-2	Perfluorodecanoic acid (PFDA)	NA	--	0.300	0.200	0.089	74	124	30
Isotope Dilution Method	307-55-1	Perfluorododecanoic acid (PFDoA)	NA	--	0.300	0.200	0.100	75	123	30
	375-85-9	Perfluoroheptanoic acid (PFHpA)	NA	--	0.300	0.200	0.078	76	124	30
	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	NA	--	0.300	0.200	0.062	75	121	30
	307-24-4	Perfluorohexanoic acid (PFHxA)	NA	--	0.300	0.200	0.071	75	125	30
	375-95-1	Perfluorononanoic acid (PFNA)	NA	--	0.300	0.200	0.081	74	126	30
	1763-23-1	Perfluorooctanesulfonic acid (PFOS)	126/609	EPA Soil/Sediment	1.00	0.500	0.240	69	131	30
	335-67-1	Perfluorooctanoic acid (PFOA)	126/609	EPA Soil/Sediment	0.300	0.200	0.100	76	121	30
	72629-94-8	Perfluorotridecanoic Acid (PFTriA)	NA	--	0.300	0.200	0.100	43	116	30
	376-06-7	Perfluorotetradecanoic acid (PFTeA)	NA	--	0.400	0.300	0.110	22	129	30

QAPP Worksheet #15-2A - Continued

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit (µg/Kg)	Project Action Limit Reference[2]	LOQ (µg/Kg)	LOD (µg/Kg)	DL (µg/Kg)	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
	2991-50-6	N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	NA	--	2.00	1.00	0.300	65	135	30
	2355-31-9	N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	NA	--	2.00	1.00	0.300	65	135	30
	27619-97-2	1H, 1H, 2H, 2H-perfluorooctane sulfonate (6:2 FTS)	NA	--	4.00	2.00	0.660	65	135	30
	39108-34-4	1H, 1H, 2H, 2H-perfluoroecane sulfonate (8:2 FTS)	NA	--	2.00	1.00	0.300	65	135	30

Source: Test America Sacramento - March 25, 2018

[1] See Worksheet #23 for Analytical SOP References

EPA - Region 1 Memorandum: Site-Specific Screening Levels for PFOA, PFOS, and PFBS for the Fort Devens NPL Site, 2/28/18.

Notes:

NA = not available
PFAS = per- and polyfluoroalkyl substances
CAS = Chemical Abstract Service
LOQ = limit of quantitation
LOD = limit of detection
LCS = laboratory control sample
MS = matrix spike
MSD = matrix spike duplicate
µg/Kg = microgram per kilogram
RPD = relative percent difference
DL = detection limit

QAPP WORKSHEET #15-2B: ANALYTICAL METHOD REPORTING LIMITS AND CONTROL LIMITS

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit (µg/Kg)	Project Action Limit Reference[2]	LOQ (µg/Kg)	LOD (µg/Kg)	DL (µg/Kg)	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
Soil	2058-94-8	Perfluoroundecanoic acid (PFUnA)	NA	--	0.500	0.250	0.090	70	130	30
Post-TOP Assay	375-73-5	Perfluorobutanesulfonic acid (PFBS)	126,000	EPA	0.500	0.250	0.063	70	130	30
PFAS Analysis by LC/MS/MS	335-76-2	Perfluorodecanoic acid (PFDA)	NA	--	0.500	0.250	0.055	70	130	30
Isotope Dilution Method	307-55-1	Perfluorododecanoic acid (PFDoA)	NA	--	0.500	0.250	0.170	70	130	30
	375-85-9	Perfluoroheptanoic acid (PFHpA)	NA	--	0.500	0.250	0.073	70	130	30
	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	NA	--	0.500	0.250	0.078	70	130	30
	307-24-4	Perfluorohexanoic acid (PFHxA)	NA	--	0.500	0.250	0.110	70	130	30
	375-95-1	Perfluorononanoic acid (PFNA)	NA	--	0.500	0.250	0.090	70	130	30
	1763-23-1	Perfluorooctanesulfonic acid (PFOS)	126	EPA	1.25	0.625	0.500	70	130	30
	335-67-1	Perfluorooctanoic acid (PFOA)	126	EPA	0.500	0.250	0.220	70	130	30
	72629-94-8	Perfluorotridecanoic Acid (PFTriA)	NA	--	0.500	0.250	0.130	70	130	30
	376-06-7	Perfluorotetradecanoic acid (PFTeA)	NA	--	0.500	0.250	0.140	70	130	30

QAPP Worksheet #15-2B - Continued

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit (µg/Kg)	Project Action Limit Reference[2]	LOQ (µg/Kg)	LOD (µg/Kg)	DL (µg/Kg)	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
	2991-50-6	N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	NA	--	5.00	2.50	0.930	70	130	30
	2355-31-9	N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	NA	--	5.00	2.50	0.980	70	130	30
	27619-97-2	1H, 1H, 2H, 2H-perfluorooctane sulfonate (6:2 FTS)	NA	--	5.00	2.50	0.380	70	130	30
	39108-34-4	1H, 1H, 2H, 2H-perfluoroecane sulfonate (8:2 FTS)	NA	--	5.00	2.50	0.630	70	130	30

Source: Test America Sacramento - March 25, 2018

[1] See Worksheet #23 for Analytical SOP References

EPA - Region 1 Memorandum: Site-Specific Screening Levels for PFOA, PFOS, and PFBS for the Fort Devens NPL Site, 2/28/18.

Notes:

NA = not available
PFAS = per- and polyfluoroalkyl substances
CAS = Chemical Abstract Service
LOQ = limit of quantitation
LOD = limit of detection
LCS = laboratory control sample
MS = matrix spike
MSD = matrix spike
µg/Kg = microgram per kilogram
RPD = relative percent difference
DL = detection limit

QAPP WORKSHEET #15-3: ANALYTICAL METHOD REPORTING LIMITS AND CONTROL LIMITS DRINKING WATER SAMPLES

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit (ng/L)	Project Action Limit Reference[2]	LOQ (ng/L)	LOD (ng/L)	DL (ng/L)	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
Drinking Water	2058-94-8	Perfluoroundecanoic acid (PFUnA)	NA	--	2.00	0.80	0.218	70	130	30
PFAS Analysis by LC/MS/MS	375-73-5	Perfluorobutanesulfonic acid (PFBS)	40,100	EPA	2.00	1.6	0.650	70	130	30
Drinking Water Method 537 Revision1.1	335-76-2	Perfluorodecanoic acid (PFDA)	NA	--	2.00	0.80	0288	70	130	30
	307-55-1	Perfluorododecanoic acid (PFDoA)	NA	--	2.00	0.80	0.284	70	130	30
	375-85-9	Perfluoroheptanoic acid (PFHpA)	NA	--	2.00	0.80	0.238	70	130	30
	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	NA	--	2.00	0.80	0.328	70	130	30
	307-24-4	Perfluorohexanoic acid (PFHxA)	NA	--	2.00	1.6	0.404	70	130	30
	375-95-1	Perfluorononanoic acid (PFNA)	NA	--	2.00	0.80	0.257	70	130	30
	1763-23-1	Perfluorooctanesulfonic acid (PFOS)	70/40.1	LHA/EPA	2.00	0.80	0.225	70	130	30
	335-67-1	Perfluorooctanoic acid (PFOA)	70/40.1	LHA/EPA	2.00	0.80	0.261	70	130	30
	72629-94-8	Perfluorotridecanoic Acid (PFTriA)	NA	--	2.00	1.6	0.576	70	130	30
	376-06-7	Perfluorotetradecanoic acid (PFTeA)	NA	--	2.00	1.6	0.515	70	130	30
	2991-50-6	N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	NA	--	2.00	1.6	0.595	70	130	30
	2355-31-9	N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	NA	--	2.00	1.6	0.636	70	130	30

Source: Alpha Analytical, June 2018

[1] See Worksheet #23 for Analytical SOP References

[2] LHA - Federal Register; Vol.81 #101, May 2016

EPA - Region 1 Memorandum: Site-Specific Screening Levels for PFOA, PFOS, and PFBS for the Fort Devens NPL Site, 2/28/18.

Notes:

NA = not available
PFAS = per- and polyfluoroalkyl substances
CAS = Chemical Abstract Service
LOQ = limit of quantitation
LCS = laboratory control sample
MS = matrix spike
MSD = matrix spike duplicate
ng/L = nanogram per liter
DL = detection limit

LOD = limit of detection

RPD = relative percent difference

QAPP WORKSHEET #15-4: ANALYTICAL METHOD REPORTING LIMITS AND CONTROL LIMITS

Analytical Method[1]	CAS Number	PFAS Compound	Project Action Limit	LOQ	LOD	DL	Units	Control Limits (LCS, MS, MSD)		Precision (RPD, %)
Groundwater/Surface Water										
DOC analysis in aqueous samples	7440-44-0	Dissolved Organic Carbon (DOC)	NA	1.0	0.50	0.19	mg/L	88	112	20
Soil/Sediment										
TOC analysis in soil samples	7440-44-0	Total Organic Carbon (TOC)	NA	2,000	100	44.4	mg/Kg	50	140	35

Source: Test America Sacramento - March 25, 2018

[1] See Worksheet #23 for Analytical SOP References

[2] LHA - Federal Register; Vol.81 #101, May 2016

EPA - Region 1 Memorandum: Site-Specific Screening Levels for PFOA, PFOS, and PFBS for the Fort Devens NPL Site, 2/28/18.

Notes:

NA = not available
PFAS = per- and polyfluoroalkyl substances
CAS = Chemical Abstract Service
LOQ = limit of quantitation
LOD = limit of detection
LCS = laboratory control sample
MS = matrix spike
MSD = matrix spike duplicate
mg/Kg = milligram per kilogram
mg/L = milligram per Liter
DL = detection limit
RPD = relative percent difference

QAPP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

Sampling Design and Rationale

The sampling and analysis will be completed to gather the data to achieve the DQOs (Worksheet #11). The design of the sampling program and rationale for the areas of investigation is presented in each Area-specific FSP Addendum. If further investigation is warranted after receiving and reviewing results, the field program may be expanded to include the sampling of additional existing monitoring wells, the collection of samples from new groundwater vertical profile borings and/or soil boring, and/or installation of new monitoring wells.

Field Activities

Groundwater from monitoring wells will be purged and sampled in accordance with the Region 1, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells (USEPA Region 1, 2017) and KGS-SOP-F003 (Groundwater Sampling). Water quality parameters will be recorded for dissolved oxygen, specific conductance, oxidation-reduction potential, temperature, pH, and turbidity in accordance with KGS-SOP-F003. Prior to sampling, each well condition will be evaluated and depth to water measurement recorded in accordance with KGS-SOP-F002 (Evaluation of Existing Monitoring Wells and Water Level Measurement. Samples will be collected from each residential, water supply well or extraction well port in accordance with KGS-SOP-F016 (Private and Water Supply Well Sampling). The stringent sampling procedures required for PFAS sampling are detailed in the KGS-SOP-F009 (PFAS Sampling). Surface water and sediment samples will be collected in accordance with KGS-SOP-F004 (Sediment-Surface Water Sampling). Shallow and surface soil samples will be collected in accordance with KGS-SOP-F015 (Soil Sampling – Surface and Shallow Depth). Samples collected will be handled in accordance with KGS-SOP-F008 (Sample Handling). Equipment will be decontaminated in accordance with KGS-SOP-F005 (Decontamination of Field Equipment). Field activities using direct push technology, vertical profiling and some soil sampling, will be conducted in accordance with KGS-SOP-F012 (Direct Push Technology). Monitoring wells will be construction and developed in accordance with KGS-SOP-F017 (Monitoring Well Construction and Development). Soils will be described in accordance with KGS-SOP-F018 (Soil Description). Samples will be analyzed for the analyses listed in the Area-specific FSP addendum for each media.

Vertical Profiling

Groundwater samples will be collected via vertical profiling using direct push technology. Temporary screens will be advanced using a Geoprobe® drill rig and SP22® groundwater sampler. Direct Push technology will be used to advance the SP22® sampler to the appropriate depth. Attachment A includes SOPs for the Geoprobe® SP22® sampling device. Temporary well groundwater samples shall be collected using the following procedure:

- Advance a 2.25-inch outer casing equipped with an expendable drive point into the appropriate depth using direct-push tooling and drill rig;
- Lower a 48-inch stainless steel screen to total depth inside the outer casing;

- Retract the outer casing to expel the expendable drive point and expose two feet of the screen;
- Measure the water level inserting a decontaminated electronic water level meter inside the inner rods and monitor the water level until it appears to stabilize;
- If necessary, the screen will be raised to coincide with the water table;
- Insert new high-density polyethylene tubing (HDPE) tubing into the screened interval to collect a groundwater sample via either a check valve sampling method or peristaltic pump;
- Measure field parameters and collect groundwater sample by filling sample containers directly from tubing;
- Remove tubing and direct-push tooling with screened-tip from the borehole and decontaminate equipment with Alconox or Liquinox and de-ionized water. Dispose of tubing.
- The process will be repeated for subsequent depths.

Where boreholes for soil sampling and groundwater sampling are collocated and as feasible, the borehole for the groundwater sample will be a continuation of the borehole used to collect the collocated shallow soil samples; otherwise, the groundwater sample borehole will be installed within 3 feet of the soil sample borehole.

As noted in Attachment A, most of the components of the Geoprobe® SP22® sampling device are comprised of stainless steel; however, several O-rings of unknown construction are depicted. Prior to sampling, the drilling subcontractor will be consulted regarding the O-ring material and its potential to cause false-positive PFAS detection in groundwater samples. If the potential for false positives is uncertain, then a field blank sample will be collected of PFAS free, de-ionized water run through the sampling device.

Boreholes will be abandoned after sample collection by filling the entire length of the borehole with cement-bentonite grout.

Groundwater sample collection will include using disposable non-Teflon tubing and pumps.

Sample Analysis

Various analysis will be used including analysis for PFAS, TOC, DOC, grain size. Groundwater and soil samples from select locations will be processed by the laboratory through a total oxidizable precursor (TOP) assay. The total oxidizable precursor assay (TOP) converts polyfluorinated precursors into fully fluorinated compounds (PFOS and PFOA) using a hydroxyl radical-based chemical oxidation method. The TOP assay replicates what micro-organisms in the environment would achieve after many years. Two sets of sample results will be reported for these samples. The difference between PFAS concentrations before (Pre-TOP) and after (Post-TOP) oxidation can be used to estimate the concentration of the non-discrete oxidizable precursors in the sample. The results will allow evaluation of the total PFOS and PFOA mass in each sample through evaluation of the presence of PFOS and PFOA along with other PFAS compounds that

degrade into PFAS compounds including PFOS and PFOA. The results will be used in evaluation of potential continuing sources.

Sample Nomenclature

The nomenclature for identifying locations, samples collected in the field, and quality assurance/quality control (QA/QC) samples is presented below.

Location Identifier

All new locations will be assigned a unique location identifier (ID), which will identify the specific point where measurements or samples are collected. Location IDs for new locations will be assigned prior to the sampling event. The location ID will include codes to identify the AOC or area of investigation, the location type, year established, and the location number.

The AOC or areas of investigation may be two- or three-characters and will be numbers or letters. Examples include "74" for AOC 74, "CSB" for Cold Spring Book, and "GP" for Grove Pond.

The location types are listed below.

SB – Soil Boring

VP – Vertical Profile

M – Monitoring Well

The year established will be indicated by two numerals, such as "18" to indicate 2018. The location number will be a unique sequential number for respective locations established within each AOC or area of investigation. The location ID for the second vertical profile conducted at AOC 75 in 2018 would be "75VP-18-02".

Surface water and sediment locations will be assigned location IDs designating the area of investigation only. For example, the location ID for a surface water/sediment location established at Cold Spring Brook would be "CSB-18-01".

Field Sample ID

A unique field sample ID will incorporate the location ID, described above, and will be used to identify individual field samples collected for a specific sampling event. The field sample ID will be used on sample labels, chain of custody forms, field logbooks, field sheets and other applicable documentation. The field sample IDs will include the location ID appended with a sample matrix code (for soil samples collected from monitoring well borings and surface water and sediment samples), and sample depth or sample date code (depending on the location type).

The sample matrix codes include:

SO – soil

SED – sediment

SW – surface water

A sample depth code will be used for soil samples and groundwater samples collected via vertical profiling. The depth will represent the depth interval of the sample with respect to feet below ground surface (ft bgs).

A sample date code (MONYY) will be used for groundwater samples collected from monitoring wells and for surface water and sediment samples to identify the sampling events and to aid in comparison of results from the same location. The sample date code will be represented by three letters representing the month and two digits representing the year the sample was collected.

The following are examples of field sampling IDs:

GPVP-18-02-25-27 represents a groundwater sample collected from the second 2018 vertical profile location at Grove Pond collected from 25 to 27 ft bgs.

75SB-18-01-0-0.5 represents a soil sample collected from the first 2018 soil boring location at AOC 75 collected from 0 to 0.5 ft bgs.

74M-19-02X-SO-55-56 represents a soil sample collected from 55 to 56 ft bgs during drilling for the second monitoring well installed at AOC 74 in 2019.

5701M-19-03-FEB19 represents a groundwater sample collected in February 2019 from the third 2019 monitoring well installed at AOC 57 Area 1.

CSB-18-04-SED-DEC18 represents a sediment sample collected in December 2018 from the fourth Cold Spring Brook location.

Field Quality Assurance/Quality Control Samples

Quality assurance/quality control (QA/QC) samples will be designated to indicate the type of QA/QC sample. The QA/QC sample IDs will include the AOC or area of investigation, location types or sample matrix, QA/QC sample type, and sequential numbering (01, 02, 03).

The QA/QC sample types will include the following and be identified as:

DUP – Field Duplicate

FRB – Field Reagent Blank

EB – Equipment Rinseate Blank

Field duplicate samples will include the AOC or area of investigation and the location type or sample matrix appended with DUP01, DUP02 etc. For example, the field sample ID for a field duplicate sample collected from soil boring location 74SB-18-01 would be "74SB-DUP01". A field reagent blank sample associated with vertical profile samples from AOC 74 would be "74VP-FRB01". Matrix spike and matrix spike duplicate samples (MS/MSD) will be identified in the notes of the chain of custody; the laboratory will append MS or MSD to the sample ID for reporting.

The specific location IDs and field sample IDs are presented in each Area-specific field sampling plan addendum.

Investigation-Derived Waste Management

Investigation Derived Waste (IDW) will be handled in a manner consistent with USACE and EPA guidance for managing IDW and applicable Federal and state regulations. Waste soil generated from drilling activities will be containerized, characterized, and disposed. USACE may delegate authority to KGS via email for signature of manifest of non-hazardous waste. Signed manifest will be sent to the USACE upon signature and pick up of IDW. Any groundwater generated will be containerized and upon completion of sampling, discharged back to the ground at the site of generation. IDW will be managed in accordance with KGS-SOP-F011 (IDW Management).

QAPP WORKSHEET #18: SAMPLING LOCATIONS AND METHODS

The specific sampling matrix, number of samples to be collected, and analytical parameters for each area of investigation is presented in each Area-specific FSP Addendum.

QAPP WORKSHEET #19 AND 30: SAMPLE CONTAINERS, PRESERVATION, AND HOLD TIMES

Worksheets #19 and #30 summarize the analytical methods/matrix, required sample volume, containers, preservation, and holding time requirements. Laboratory analytical SOPs are provided in Worksheet #23 (Analytical SOP). The primary point of contact is through the Test America-Savannah laboratory. PFAS groundwater, surface water, soil, and sediment samples will be analyzed at Test America-Sacramento and DOC/TOC samples will be analyzed at Test America-Seattle. PFAS drinking water samples will be analyzed at Alpha Analytical. Grain size samples will be submitted directly to GeoTesting Expresss in Acton, MA.

Primary Analytical Laboratory
Test America
Point of Contact: Jerry Lanier, Phone: (912) 354-7858

Matrix	**Analytical Group**	**Analytical / Preparation Method SOP Reference[1]**	**Containers** (number, size, and type)	**Preservation Requirements** (chemical, temperature)	**Maximum Holding Time[2]** (preparation/analysis)
ORGANIC ANALYSES					
Groundwater, Surface Water	PFAS	WS-LC-0025 Rev 3.0 (4/13/2018) (TAL-Sacramento)	2 x 250-ml HDPE Bottles (NO Teflon lids)	Cool to 4 ± 2°C	Extraction: 14 Days from Collection Analysis: 40 days from Extraction
Sediment, Soil	PFAS	WS-LC-0025 Rev 3.0 (4/13/2018) (TAL-Sacramento)	1-4-ounce HDPE Jar	Cool to 4 ± 2°C	Extraction: 14 Days from Collection Analysis: 40 days from Extraction
Drinking Water	PFAS	SOP 23511, Revision 4 (6/29/2017) (Alpha Analytical)	2 C -250ml polypropylene Bottles (NO Teflon Lids)	Trizma® Cool to 4 ± 2°C	Extraction: 14 Days from Collection Analysis: 40 days from Extraction
MISCELLANEOUS ANALYSES					
Groundwater, Surface Water	DOC	EPA 415.1, SW9060 SOP TA-WC-156 (TAL - Seattle)	1-500-ml Amber Glass	H_3PO_4 to pH 2 Cool to 4 ± 2°C	28 days from collection.
Sediment, Soil	TOC	EPA 9060A SOP TA-WC-192 (TAL - Seattle)	1-4-ounce glass jar	Cool to 4 ± 2°C	28 days from collection.

QAPP Worksheets #19 and 30 - Continued

Primary Analytical Laboratory
Test America
Point of Contact: Jerry Lanier, Phone: (912) 354-7858

Matrix	Analytical Group	Analytical / Preparation Method SOP Reference[1]	Containers (number, size, and type)	Preservation Requirements (chemical, temperature)	Maximum Holding Time[2] (preparation/analysis)
MISCELLANEOUS ANALYSES					
Sediment, Soil	Grain size	ASTM D-422 SOP ASTM D-422-07 (GeoTesting Express)	1-1-gallon ziplock bag	Cool to 4 ± 2°C	Not specified

[1] See Worksheet #23. Laboratory SOPs are provided in Attachment B.
[2] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

QAPP WORKSHEET #20: FIELD QC SAMPLE SUMMARY

The table below provides a summary of the types of samples to be collected and analyzed. Its purpose is to show the relationship between the number of field samples and associated QC samples for each combination of analyte/analytical group and matrix. Area-specific sample locations are summarized in tables included in each Area-specific field sampling plan addendum.

Matrix	Analysis[1]	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Equipment Rinseate Blanks[2]	Field Reagent Blanks[3]
Groundwater Drinking Water	PFAS	See Area-specific FSP addendum	10%	5%	5%	One per piece of sampling equipment	PFAS-free source water
Surface Water	PFAS	See Area-specific FSP addendum	10%	5%	5%	One per piece of sampling equipment	PFAS-free source water
Soil	PFAS	See Area-specific FSP addendum	10%	5%	5%	One per piece of sampling equipment	PFAS-free source water
Sediment	PFAS	See Area-specific FSP addendum	10%	5%	5%	One per piece of sampling equipment	PFAS-free source water
Aqueous	DOC	See Area-specific FSP addendum	10%	5%	5%	One per piece of sampling equipment	NA
Soil/Sediment	TOC	See Area-specific FSP addendum	10%	5%	5%	One per piece of sampling equipment	NA
Soil/Sediment	Grain Size	See Area-specific FSP addendum	10%	NA	NA	NA	NA

[1] Field QC samples for TOP assay will not be collected.

[2] Equipment rinseate blanks (EBs) are collected by pouring PFAS-free water (supplied by the laboratory) over decontaminated sampling equipment. The frequency of EB collection should be at least once a week per area of contamination or area of investigation.

[3] Field Reagent Blanks (FRBs) are PFAS-free water poured into a sample bottle in the field at the time of sampling. The frequency of FRB collection is at least once during each sampling event per area of contamination or area or investigation.

QAPP WORKSHEET #21: FIELD SOPS

The field SOPs associated with the sampling acquisition tasks (including, but not limited to, sample collection, sample handling and custody) are listed in the following table. Copies of the field SOPs are provided in Attachment A.

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)
SOP-F001	Monitoring Equipment Calibration	KGS	N/A	N
SOP-F002	Evaluation of Existing Monitoring Wells and Water Level Measurement	KGS	Water Level Meter	N
SOP-F003	Groundwater Sampling	KGS	Various Sampling Equipment	N
SOP-F004	Sediment-Surface Water Sampling	KGS	Various Sampling Equipment	N
SOP-F005	Decontamination of Field Equipment	KGS	N/A	N
SOP-F007	Field Documentation	KGS	N/A	N
SOP-F008	Sample Handling	KGS	N/A	N
SOP-F009	PFAS Sampling	KGS	Various Sampling Equipment	N
SOP-F010	Global Positioning System (GPS) Measurements	KGS	Trimble, GeoXH	N
SOP-F011	Investigation Derived Waste (IDW) Management	KGS	Sampling Equipment, 55-gallon drums, bung wrench, drum funnel	N

QAPP Worksheet #21 - Continued

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)
SOP-F012	Pore Water Sampling	KGS	N/A	N
SOP-F013	Site-Specific Health and Safety Training	KGS	N/A	N
SOP-F014	Direct Push Technology	KGS	Various	N
SOP-F015	Soil Sampling - Surface and Shallow Depth	KGS	Stainless steel equipment, hand auger, core sampler	N
SOP-F016	Private and Water Supply Well Sampling	KGS	N/A	N
SOP-F017	Monitoring Well Construction and Development	KGS	Various	N
SOP-F018	Soil Description	KGS	N/A	N
	Geoprobe® Screen Point 22 Groundwater Sampler	Kefr, Inc.	GeoProbe	N

QAPP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION

Field sampling equipment will be leased from a reputable equipment leasing supplier. All equipment shall be received in good working order from the supplier. The field equipment and instruments expected to be used during the sampling events discussed in this QAPP may include:

- Water level meter
- Water quality instrument(s)
- Submersible pump and controller, bladder pump and controller, and peristaltic pump for sample acquisition
- Bladder pump and controller for sample acquisition
- Data logger and transducers
- Power generator
- Trimble GeoExplorer
- Camera

Additional equipment may be needed depending on field conditions. Manufacturer's calibration instructions shall be followed when using rental field equipment. The calibration, maintenance, testing, and/or inspection requirements are discussed in the field specific SOPs included in Attachment A.

QAPP WORKSHEET #23: ANALYTICAL SOP REFERENCES

Lab SOP Number	Title, Revision Date, and/or Number[1]	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
ORGANIC ANALYSES						
WS-LC-0025	Per- and polyfluorinated Substances in Water, Soils, Sediments and Tissue [Method PFAS by LCMSMS Compliant with QSM 5.1 Table B-15]. Revision 3.0 (4/13/2018)	Definitive	PFAS (Waters and Soils)	Liquid Chromatography/tandem Mass spectrometry (LC/MS/MS)	TestAmerica Sacramento[1]	N
Alpha SOP 23511	Determination of Selected Perfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)	Definitive	PFAS	LC/MS/MS	Alpha Analytical[2]	N
MISCELLANEOUS PARAMETERS						
TA-WC-0156	Determination of Total Organic Carbon in Liquid Matrices [Methods 415.1, 9060, and SM 5310B] (Revision 10, 1/8/2016)	Definitive	TOC/DOC (Waters)	TOC Analyzer	TestAmerica Seattle[3]	N
TA-WC-0192	Total Organic Carbon in Solids Using the LECO C632 Total Organic Carbon Analyzer [Methods SW846 9060 Mod, 9060A Mod and PSEP-TOC] (Revision 4, 10/4/2016)	Definitive	TOC (Solids)	TOC Analyzer	TestAmerica Seattle[3]	N
ASTM D-422-07	Test Method for Particle Size Analysis of Soils (Revision 8, January 2018)	Screening	Grain Size (Soils)	Sieves	GeoTesting Express[4]	N

[1] Test America – Sacramento - DoD ELAP Certification QSM 5.1; L2468 Issued 01/17/2018; Valid: 01/17/2018-01/20/2021.
[2] Test America – Seattle – DoD ELAP Certification QSM 5.1; L2236 Issued 11/16/2017; Valid 11/16/2017—1/19/2019.
[3] Alpha Analytical, Mansfield, MA - DoD ELAP Certification QSM 5.1, L2474 Issued 12/06/2017 – 05/30/2019.
[4] GeoTesting Express – USACE validation; December 2016.
Analytical SOPs and copies of Laboratory Certifications are provided in Attachment B and C, respectively.

QAPP WORKSHEETS #24-1: ANALYTICAL INSTRUMENT CALIBRATION (PFAS TESTAMERICA)

PFAS Analytical Instrument Calibration PFAS Lab SOP WC-LC-0025					
Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action (CA)**	**Person Responsible for CA**
LC/MS/MS	Mass Calibration	Prior to initial use and after any major maintenance is performed.	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Entire range needs to be mass calibrated	NA	Lab Manager/ Analyst [1]
LC/MS/MS	Tune Check	When the masses fall outside of the $\pm$0.5 amu of the true value. amu = atomic mass unit)	Mass assignments of tuning standard within 0.5 amu of true value by a signal to noise (S/N) ratio of 10:1 for all analytes in the lowest calibration point.	Retune instrument. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tuning redone.	Lab Manager/ Analyst [1]
LC/MS/MS	Minimum five-point initial calibration for target analytes, lowest concentration standard at or below the LOQ.	Prior to initial use and after ICV or CCV failure, prior to sample analysis.	S/N ratio $\geq$ 10:1 for all ions used for quantitation. Confirmation ions for PFOS and PFOA must have S/N $\geq$ 3:1. The %RSD for all analytes must be <20%. Linear or non-linear calibrations must have r2 $\geq$ 0.99 for each analyte. Each analyte must be within 70-130% of its true value for each calibration standard.	Evaluate standards, chromatography, and mass spectrometer response. If problem found with above, correct as appropriate, then repeat initial calibration.	Lab Manager/ Analyst [1]

QAPP Worksheets #24-1 – Continued

PFAS Analytical Instrument Calibration PFAS Lab SOP WC-LC-0025					
Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action (CA)**	**Person Responsible for CA**
LC/MS/MS	Instrument blanks	Immediately following the highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte must be $\leq$ 1/2 the LOQ.	If acceptance criteria are not met after the highest standard, the ICAL must be performed at a lower concentration until the acceptance criteria are met. If not met after samples, additional blanks are needed until the acceptance criteria are met. Samples shall not be analyzed until the acceptance criteria are met.	Lab Manager/ Analyst [1]
LC/MS/MS	Second-source or initial calibration verification (ICV)	Once after each initial calibration (ICAL) prior to sample analysis.	All reported analytes and labelled compounds within ± 30% of their true value.	Evaluate data. If problem (e.g., concentrated standard, plugged transfer line) found, correct, then repeat second source verification. If it still fails, then repeat initial calibration.	Lab Manager/ Analyst [1]
LC/MS/MS	Instrument sensitivity check (ISC)	Prior to analysis and at least once every 12 hours. ISC can serve as a bracketing CCV.	Analyte concentrations must be at the LOQ and within $\pm$ 30% of their true values.	Correct problem, rerun ISC. If problem persists repeat ICAL.	Lab Manager/ Analyst [1]

QAPP Worksheets #24-1 - Continued

PFAS Analytical Instrument Calibration PFAS Lab SOP WC-LC-0025					
Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action (CA)**	**Person Responsible for CA**
LC/MS/MS	Continuing calibration verification (CCV)	Before sample analysis, after every 10 field samples, and at the end of the sequence.	All reported analytes and labelled compounds within ± 30% of their true values.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. Or evaluate failure and impact on samples. If samples non-detect for analytes which have a high bias, report non-detect results with case narrative comment. For closing CCVs, if compounds are not identified as critical compounds of concern report results with qualifiers. For closing CCVs, if the compound is identified as a critical compound of concern, then recalibrate, and reanalyze all affected samples since the last acceptable CCV.	Lab Manager/ Analyst [1]

Source: Test America - Sacramento

[1] The analyst initiates the corrective action and the lab manager and analyst are responsible for the corrective action.

QAPP WORKSHEETS #24-2: ANALYTICAL INSTRUMENT CALIBRATION (PFAS ALPHA ANALYTICAL)

PFAS Analytical Instrument Calibration – Drinking Water Alpha PFAS Lab SOP 23511					
Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action (CA)**	**Person Responsible for CA**
LC/MS/MS	Technical PFOA and PFOS Evaluation Mixture (TPFOA/TPFOS) Branched and Linear Isomers 50 ng/ml (ppb)	When Columns are changed, LC conditions altered.	For retention time and pattern recognition (qualitative)	Adjust scanning windows as needed.	Lab Manager/ Analyst [1]
LC/MS/MS	Tune Check	When the masses fall outside of the $\pm$0.5 amu of the true value.	Mass assignments of tuning standard within 0.5 amu of true value by 10:1 S/N for all analytes in the lowest calibration point.	Retune instrument. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tuning redone.	Lab Manager/ Analyst [1]
LC/MS/MS	Initial Calibration (ICAL) Drinking water Matrices by SPE, 0.5-150 ng/ml (ppb)/ 2-600 ng/L(ppt)	Initial instrument setup; After non-routine instrument service; CCV/ICV criteria are not met	Minimum of 5 standards; Low standard must be $\leq$ RL; $r \geq 0.99$ (linear regression), or $r^2 \geq 0.99$ (non-linear regression)	Review integrations and calculations; Perform and document remedial action as required; Repeat calibration	Lab Manager/ Analyst [1]
LC/MS/MS	ICV Mid Level Cal STD, 10 ng/ml	Immediately after each ICAL.	±30% recovery of the true values Prepared using standard source different than used for initial calibration.	Re-analyze ICV if analytical error is suspected; Recalibrate as needed	Lab Manager/ Analyst [1]

PFAS Analytical Instrument Calibration – Drinking Water Alpha PFAS Lab SOP 23511					
Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action (CA)**	**Person Responsible for CA**
LC/MS/MS	CCV	Before sample analysis, after every 10 field samples, and at the end of the sequence.	The calculated amount for each analyte and surrogate for medium and high-level standards must be within ± 30% of their true values. The calculated amount for the lowest cal standard must be within ± 50%.	Immediately analyze a second CCV. If acceptable, samples may be reported without reanalysis. If CCV still fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/ Analyst

Source: Alpha Analytical, Mansfield, MA

[1] The analyst initiates the corrective action and the lab manager, QAM and/or analyst are responsible for the corrective action.

QAPP WORKSHEETS #24-3: ANALYTICAL INSTRUMENT CALIBRATION (TOC/DOC AQUEOUS)

TOC/DCO Analytical Instrument Calibration Table TA-WC-0156 (aqueous)					
Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action (CA)**	**Person Responsible for CA**
Apollo 9000	Initial calibration (IC) is performed using a 5-point standard curve and a blank standard.	According to manufacturer's instructions	The absolute value of the correlation coefficient (r) must be 0.995 or greater.	Correct problem, then repeat ICAL.	Lab Manager/ Analyst [1]
Apollo 9000	Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Within ± 15% of true value.	Check the equipment and standards, correct any problems, and then recalibrate.	Lab Manager/ Analyst [1]
Apollo 9000	Continuing Calibration Verification (CCV)	The calibration is checked at the beginning of an analytical sequence (ICV), after every ten samples (CCV), and at the end of the sequence (CCV) by measuring a CCV standard.	Within ± 15% of true value.	Check the equipment and standards, correct any problems, recalibrate, and rerun all samples analyzed since the last successful CCV.	Lab Manager/ Analyst [1]
Apollo 9000	Initial and Continuation Calibration Blank (ICB/CCB)	Before beginning a sample run, after every 10 field samples, and at the end of the analysis sequence.	No analytes detected >1/2 the LOQ	Check for carry-over from high level samples, clean the system, recalibrate, and rerun all samples analyzed since the last successful CCB.	Lab Manager/ Analyst [1]

Source: Test America -Seattle

[1] The analyst initiates the corrective action and the lab manager, QAM and/or analyst are responsible for the corrective action.

QAPP WORKSHEETS #24-4: ANALYTICAL INSTRUMENT CALIBRATION (TOC SOLIDS)

TOC Analytical Instrument Calibration Table TA-WC-0192 (solid)					
Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action (CA)**	**Person Responsible for CA**
LECO	Initial calibration (IC) per manufacturer's instructions, with a 6-point standard curve with 12% carbon standard.	Annually, or as needed. based on the instrument performance and maintenance.	The absolute value of the correlation coefficient (r) must be 0.995 or greater.	Correct problem, then repeat ICAL.	Lab Manager/Analyst [1]
LECO	Initial Calibration Verification (ICV) per manufacturer's instructions, with a low and/or high standard	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Within ± 20% of true value.	If it is outside the acceptance limits, check the equipment and standards, correct any problems, and then recalibrate.	Lab Manager/Analyst [1]
LECO	Continuing Calibration Verification (CCV) per manufacturer's instructions, with a low and/or high standard	The calibration is checked at the beginning of an analytical sequence (ICV), after every ten samples (CCV), and at the end of the sequence (CCV) by measuring a CCV standard.	Within ± 20% of true value.	If it is outside the acceptance limits, check the equipment and standards, correct any problems, recalibrate, and rerun all samples analyzed since the last successful CCV.	Lab Manager/Analyst [1]
LECO	Initial and Continuing Calibration Blank (ICB/CCB)	System cleanliness is checked at the beginning of an analytical sequence (ICB), after every ten samples (CCB), and at the end of the sequence (CCB) by analyzing a blank.	No analytes detected >LOQ	If the blank result is greater than the reporting limit, check for carry-over from high level samples, clean the system, recalibrate, and rerun all samples analyzed since the last successful CCB.	Lab Manager/Analyst [1]

Source: Test America - Seattle

[1] The analyst initiates the corrective action and the lab manager, QAM and/or analyst are responsible for the corrective action.

QAPP WORKSHEETS #25-1: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION (PFAS – TESTAMERICA)

Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table (PFAS) SOP WS-LC-0025							
Instrument/ Equipment	**Maintenance Activity**	**Testing Activity**	**Inspection Activity**	**Frequency**	**Acceptance Criteria**	**Corrective Action**	**Responsible Person**
LC/MS/MS	Replace columns as needed, check eluent reservoirs	Sensitivity check	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	TestAmerica Analyst

See Worksheet #23 for list of Analytical SOPs.

QAPP WORKSHEETS #25-2 ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION (PFAS – ALPHA)

PFAS Analytical Instrument Calibration – Drinking Water Alpha PFAS Lab SOP 23511							
Instrument / Equipment	**Maintenance Activity**	**Testing Activity**	**Inspection Activity**	**Frequency**	**Acceptance Criteria**	**Corrective Action**	**Responsible Person**
LC/MS-MS (PFAS)	Isolator Column	ICAL/CCAL; overall chromatogram	Instrument performance and sensitivity	Frequency is dependent on degree of contamination and standard recovery	See SOP	See SOP	Analyst or Section Supervisor
LC/MS-MS (PFAS)	LC Column	ICAL/ CCAL; overall chromatogram	Instrument performance and sensitivity	Frequency is dependent on degree of contamination and standard recovery	See SOP	See SOP	Analyst or Section Supervisor
LC/MS-MS (PFAS)	Clean Cone assembly	ICAL/CCAL; overall chromatogram	Instrument performance and sensitivity	Frequency is dependent on degree of contamination and standard recovery	See SOP	See SOP	Analyst or Section Supervisor
LC/MS-MS (PFAS)	Source/coil cleaning.	Tuning/Mass Calibration	Instrument performance and sensitivity	Annually unless contamination warrants greater frequency.	See SOP	See SOP	Analyst or Section Supervisor

QAPP WORKSHEETS #25-3: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION (TOC/DOC)

Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table (DOC/TOC) SOPs TA-WC-0156/TA-WC-0192							
Instrument/ Equipment	**Maintenance Activity**	**Testing Activity**	**Inspection Activity**	**Frequency**	**Acceptance Criteria**	**Corrective Action**	**Responsible Person**
Apollo 9000	Check gas flow	Preventative maintenance	Preventative Maintenance	As needed	None	Replace gas tank, or repair gas leaks	Test America Analyst
Apollo 9000	Replace "O" rings	Preventative maintenance	Preventative Maintenance and when a leak is noted	As required	None	Replace "O" rings	Test America Analyst
Apollo 9000	Check needle	Preventative maintenance	Preventative Maintenance	Daily	None	Replace needle	Test America Analyst
Apollo 9000	Replace scrubbers	Preventative maintenance	Preventative Maintenance	Yearly	None	Replace scrubbers	Test America Analyst
Apollo 9000	Replace catalyst	Preventative maintenance	Preventative Maintenance	As required	None	Replace catalyst	Test America Analyst
LECO	Replace scrubbers	Preventative maintenance	Preventative Maintenance	As needed	None	Replace scrubbers	Test America Analyst

See Worksheet #23 for list of Analytical SOPs.

QAPP WORKSHEETS #26 & 27: SAMPLE HANDLING, CUSTODY, AND DISPOSAL

Sampling Organization: KOMAN Government Solutions (KGS) Team
Laboratories: Test America – Sacramento (PFAS), Test America – Seattle (DOC/TOC), Alpha Analytical (PFAS), and GeoTesting Express (Grain Size)
Method of sample delivery (shipper/carrier): Test America - sample courier, sample drop off and/or Fedex overnight, Alpha Analytical – sample courier, GeoTesting Express – sample courier
Number of days from reporting until sample disposal: 30 days from invoice

Activity	Description	Organization responsible for the activity
Sample labeling	Sample labels will be affixed to each sample collected to identify the field sample with the following information: unique sample identification number, analytical method, sampler's initials, date and time collected, and preservation method used.	KGS field team
Chain-of-custody form completion	KGS will maintain the chain-of-custody records for all normal field and QC samples. A sample is defined as being under a person's custody if any of the following conditions exist: • It is in their possession/view; • It was placed in a locked location; • It is in a designated secure area The following sample information will be documented on the chain-of-custody form: • Unique sample identification • Date and time of sample collection • Source of sample (including location/sample ID, and sample type) • Analyses required • Preservative used • Designation of matrix spike/matrix spike duplicate (MS/MSD) Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratory.	KGS field team

Activity	Description	Organization responsible for the activity
Packaging and Shipping	Samples for PFAS, TOC, DOC analysis - Sample containers will be placed inside sealed plastic bags as a precaution against cross-contamination caused by leakage or breakage. Bagged sample containers will be placed in insulated coolers with bubble wrap or other wrapping to eliminate the chance of breakage during delivery or shipment. Ice in plastic bags will be placed in the coolers to keep the samples between 2 and 6 ºC throughout storage and shipment. Sample delivery or shipment will be performed in strict accordance with all applicable U.S. Department of Transportation regulations. The samples will be transported from the site to the laboratory by laboratory personnel or shipped to the laboratory by an overnight courier service. Soil samples collected for grain size analysis will be placed in coolers and delivered to Geo Testing Express in Acton, MA or picked up by a courier.	KGS team, Test America courier, Alpha Analytical courier and/or Geo Testing Express courier
Sample receipt, inspection, & log-in	A designated laboratory representative will accept the shipped samples and verify that the received samples match those on the chain-of-custody record. The condition, temperature, and preservation of the samples should be checked and documented on the chain-of-custody form. Any anomalies in the received samples and their resolution should be documented in the laboratory records. All sample information will then be entered into a tracking system, and unique laboratory sample identifiers will be assigned. The laboratory must supply sample receipt confirmation within 24 hours of sample receipt that includes the following: • A fully executed copy of the chain-of-custody received with the samples; • Sample acknowledgement and log-in report; • Cooler and sample receipt form noting any problems, breakages, holding time issues, temperature exceedances, or inconsistencies between the chain of custody.	Test America, Alpha Analytical, Geo Testing Express

Activity	Description	Organization responsible for the activity
Sample custody and storage	Sample holding-time tracking begins with the collection of samples and continues until the analysis is complete. Holding times for analytical methods required for this project are specified in Worksheet #19 and #30 (Sample Containers, Preservation and Hold Times). Analytical batches will be created, and laboratory QC samples will be introduced into each batch. Samples will be stored in limited-access, temperature-controlled areas.	Test America Alpha Analytical, Geo testing Express,
Sample disposal	Samples will be stored for 30 days after analysis and reporting, at which time the samples will be disposed of. Organic sample extracts will be stored for 30 days, if sufficient volume remains. The samples will be disposed of by the laboratory in accordance with applicable local, state, and federal regulations. Disposal records will be maintained by the laboratory. SOPs describing sample control and custody will be maintained by the laboratory.	Test America Alpha Analytical, Geo testing Express,

QAPP WORKSHEETS #28-1: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (PFAS TESTAMERICA)

Matrix	Aqueous/Solid
Analytical Group	PFAS
SOP Reference	TAL SOP WS-LC-0025

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	No target analytes ≥ ½ LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Verify instrument clean (evaluate instrument blanks & samples prior to method blank), then reanalyze. Evaluate to determine if systematic issue within laboratory, correct, then re-prepare and reanalyze the method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements.	Test America Lab Manager / Analyst	Accuracy/Bias Contamination	No target analytes ≥ LOQ
Extracted Internal Standards (Isotope Dilution Analytes (IDA), spiked prior to extraction)	Every sample, standard, blank and QC sample.	% recovery for each IDA in the original sample (prior to dilutions) must be within 50 - 150% of the true value.	If recoveries are acceptable for QC samples, but not field samples, the field samples must be re-prepped and reanalyzed (greater dilution may be needed). If recoveries are unacceptable for QC samples, correct problem, and reanalyze all associated failed field samples.	Test America Lab Manager / Analyst	Accuracy/Bias	50-150 %R

QAPP WORKSHEET #28 – 1 – Continued

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Injection Internal Standards (added to sample aliquot just prior to analysis).	Every sample, spiked sample, standard, and method blank	Peak areas must be within ±50% of the area measured in the ICAL midpoint standard or the peak area measured in the daily CCV.	If peak areas are unacceptable reanalyze the sample. If the second analysis meets acceptance criteria, report the second analysis. If it fails, either analysis may be reported with the non-conformance noted in the case narrative.	Test America Lab Manager / Analyst	Accuracy/Bias	50-150 %R
Laboratory Control Sample (LCS)	One LCS per preparation batch	Laboratory statistically derived control limits. (Worksheet #15)	Reanalyze LCS once. If acceptable, report. If LCS has high bias, and samples are non-detect, report with case narrative comment. If LCS has low bias, or if there are detections for critical chemicals of concern, evaluate and re-prep and reanalyze the LCS and all samples in the associated prep batch for failed analytes, if sufficient sample material is available.	Test America Lab Manager / Analyst	Precisions and Accuracy/Bias	Laboratory statistically derived control limits
Matrix Spike/Matrix Spike Duplicate (MS/MSD) for all analytes	One MS/MSD pair per preparation batch. Sample spiked with all analytes at a concentration ≥LOQ and ≤ the mid-level calibration standard.	Laboratory statistically derived control limits **(**Worksheet #15)	Evaluate the data and re-prepare/reanalyze the native sample and MS/MSD pair if laboratory error is indicated.	Test America Lab Manager / Analyst	Precision and Accuracy/Bias	Laboratory statistically derived control limits

QAPP WORKSHEETS #28-2: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (PFAS ALPHA ANALYTICAL)

Matrix	Aqueous – Drinking Water
Analytical Group	PFAS
SOP Reference	Alpha SOP 23511

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch up to 20 samples.	No target analytes ≥ 1/3rd LOQ	Identify source and attempt to eliminate Reextract and/or reanalyze blank and affected samples (if sufficient sample remains). Report data if sample results >5X blank or sample results ND. If contamination is widespread or recurring, analyses must be stopped, and the source must be eliminated or reduced before analyses can continue. Qualify data, if needed.	Lab Manager / Analyst	Accuracy/Bias Contamination	No target analytes ≥ LOQ
LCS	One LCS per preparation batch up to 20 samples. Alternate spiking concentration from batch to batch at a low, medium and high concentration.	50-150% recovery for the low LCS. 70-130% recovery for the medium and high LCS.	Reanalyze LCS once. If acceptable, report. Discuss in case narrative.	Lab Manager / Analyst	Precisions and Accuracy/Bias	Laboratory control limits

QAPP WORKSHEET #28 –2 – Continued

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MS/MSD for all analytes	One MS/MSD pair per preparation batch of up to 20 samples. Alternate spiking concentration from batch to batch at a low, medium and high concentration.	50-150% recovery for the low LCS. 70-130% recovery for the medium and high LCS. RPD ≤ 30% for compounds > than 2X the LOQ. RPD ≤ 50% for compounds above the LOQ but < than 2X the LOQ.	Evaluate the data and re-prepare/reanalyze the native sample and MS/MSD pair if laboratory error is indicated.	Lab Manager / Analyst	Precision and Accuracy/Bias	Laboratory control limits
Surrogates	Every sample, standard, blank and QC sample.	70-130% recovery/	If a surrogate fails, report all results for the sample as suspect. (per method 537)	Lab Manager/ Analyst	Accuracy/ Bias	Method 537 control limits

QAPP WORKSHEETS #28-3: PFAS ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION (TOC/DOC)

Matrix	Aqueous/Solid
Analytical Group	DOC/TOC
Method/ SOP Reference	EPA Method 9060, 9060A, SM5310B TA-WC-0156 (aqueous) TA-WC-0192 (solid)

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method blank	One per batch	No target analytes ≥ ½ LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Verify instrument clean (evaluate calibration blank & samples prior to method blank), then reanalyze. Evaluate to determine if systematic issue within laboratory, correct, then re-prepare and reanalyze the method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements	Lab Manager/Analyst	No target analytes ≥ ½ LOQ in accordance with DoD QSM requirements	No target analytes ≥ ½ LOQ in accordance with DoD QSM requirements
Laboratory Control Sample	One per batch	Laboratory statistically derived control limits (Worksheet #15)	Evaluate LCS data and reanalyze if bias appears instrument related. If bias appears preparation related, determine if trend requires correction prior to re-prep and reanalysis of the LCS and all samples in the associated prep batch for failed analytes, if sufficient sample material is available.	Lab Manager/Analyst	Precisions and Accuracy/Bias	Recovery within laboratory statistically derived control limits

QAPP WORKSHEET #28 –3 – Continued

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Matrix Spike/ Matrix Spike Duplicate (MS/MSD)	One MS/MSD pair per QC batch	Laboratory statistically derived control limits (Worksheet #15)	Evaluate the data and re-prepare/reanalyze the native sample and MS/MSD pair as indicated.	Lab Manager/Analyst	Precision and Accuracy/Bias	Recovery within laboratory statistically derived control limits

QAPP WORKSHEETS #29: PROJECT DOCUMENTS AND RECORDS

The required project documents generated during every aspect of the field program are identified in this worksheet and consist of the following: (1) sample collection and field measurement records, (2) analytical records, and (3) data assessment records.

Sample Collection and Field Measurement Records

Sample collection and field measurement records generally include field logbooks, sampling field sheets, photo documentation (as needed), equipment decontamination records, sampling instrument calibration records, boring logs, well construction diagrams, correspondence, and chain-of- custody forms. These field records are copied and provided to the project manager or designee on a weekly basis. Hardcopies will be maintained in project files at KGS Marlborough office. Electronic copies of all field records will be stored on the secure project server.

Analytical Records

Analytical Data Deliverables

PDF deliverables (no hardcopy data required) from the analytical laboratory will be provided with a summary format forms package plus all associated raw supporting data. The format deliverable may be equivalent to those specified in the latest versions of EPA Contract Laboratory Program Statements of Work for Organic Analyses or as defined in the DoD QSM version 5.1 (DoD, 2017). The following information will be provided in the data package:

- Cover letter complete with the following information:
  - Report title and laboratory unique report identification (sample delivery group [SDG] number)
  - Project name and site location
  - Name and location of laboratory
  - Client name and address
  - Statement of authenticity and official signature and title of person authorizing report release
- Table of contents
- Case narrative that addresses the following information at a minimum:
  - Sample receipt discrepancies that may affect data usability, such as temperature exceedances, etc.
  - Table summarizing samples received, correlating field sample numbers, laboratory sample numbers, and laboratory tests completed
  - Descriptions of nonconformances in the sample handling, preparation, analytical, and reporting processes and the corrective action taken in each occurrence
  - Identification of samples and analytes for which manual integration was necessary
  - Discussion of all qualified data and definition of qualifying flags
- Analytical Data Report that includes the following information:
- Sample result forms to include:
  - field sample ID,
  - date received,
  - date prepared,
  - date and time of analysis,

  - method,
  - dilution factor, if needed,
  - sample-specific results with LOQ and MDL, units
  - surrogate percent recoveries.
- QC Sample Result Forms:
  - MS/MSD and LCS spike concentrations, native sample results, spiked sample results, percent recoveries, and RPD between the MS and MSD results; associated QC limits also must be provided,
  - Method blank results,
  - Internal standard recovery and retention time information, as applicable,
  - Surrogate percent recovery, as applicable.
- Analytical Batch information:
  - Analytical sequence or laboratory run log that contains sufficient information to correlate samples reported in the summary results to the associated method QC information, such as initial and continuing calibration analyses,
  - Initial calibration summary, including standard concentrations, response factors (RFs), average RFs, relative standard deviations (RSDs) or correlation coefficients, and calibration plots or equations, if applicable,
  - CCV summary, including expected and recovered concentrations and percent differences,
  - Instrument tuning and mass calibration information as applicable,
  - Sample preparation logs,
  - LC/MS/MS chromatograms for each sample (or blank) analyzed,
  - Executed chain of custody and sample receipt checklist.

The data for this project will be collected and documented in such a manner that will allow the generation of data packages that can be used to reconstruct the analytical process. The PDF data packages for each sampling event will be stored on the secure project server.

Electronic Analytical Record Format

The laboratory will provide an electronic data deliverable (EDD) in an excel spreadsheet as defined by the KGS project chemist. All electronic data submitted by the analytical laboratory will be error free and in complete agreement with the PDF version. Alternate EDD formats may be required as specified by the USACE.

KGS will update and maintain an Access database for all analytical data collected as part of this sampling effort. The database will be portable and readily accessible; updated versions will be made available to the team when requested.

Data Assessment Records

Data assessment records include, but are not limited to, data validation reports and corrective action reports.

QAPP WORKSHEETS #31, #32 & #33: ASSESSMENTS AND CORRECTIVE ACTIONS

Periodic assessments may be performed during the course of the project so that the planned project activities are implemented in accordance with this UFP-QAPP. The routine data quality verification steps described in Worksheet #34 will be used to assess the effectiveness of the project data reporting system. No additional project assessment activities are planned in the project scope. If additional assessments become necessary; this worksheet will be amended as needed.

Assessment Type	Responsible Party and Organization	Frequency	Assessment Deliverable	Timeframe of Response	Person(s) Responsible for Response and Implementing Corrective Actions	Person(s) Responsible for Monitoring Corrective Action Implementation
Field Procedure Assessment	Kevin Anderson or designee/KGS	Weekly	Internal e-mail	1 business day	Kevin Anderson or designee/KGS	Katherine Thomas/KGS
Field Documentation Reviews	Lynne Klosterman/KGS	Weekly	Internal e-mail	3 business days	Kevin Anderson or designee/KGS	Lynne Klosterman/KGS
Sample Condition Report/ Log in receipt	Laurie Ekes/KGS	After sample receipt at laboratory.	External e-mail, if laboratory issue. Internal e-mail, if KGS issue.	24 hours after notification	Laboratory log in personnel, if sample ID error, or Kevin Anderson or designee/KGS, if sample collection issue.	Lynne Klosterman/KGS
Analytical Discrepancy	Laurie Ekes/KGS	After data receipt from laboratory and during data validation.	External e-mail	7 business days	Jerry Lanier/Test America Jim Occhalini/Alpha Analytical Mark Dobday/GeoTesting	Laurie Ekes/KGS
Data Validation Reports	Laurie Ekes/KGS	Prepared for each Sample Delivery Group (SDG).	Data Validation reports and validated data spreadsheet per SDG.	3 weeks after receipt of completed data package.	Laurie Ekes/KGS	Katherine Thomas/KGS

QAPP WORKSHEET #34: DATA VERIFICATION AND VALIDATION INPUTS

To confirm that scientifically sound data of known and documented quality are used in making project decisions. This worksheet establishes the procedures that will be followed to verify and validate project data including, but are not limited to, sampling documents and analytical data packages.

Item	Description	Verification (completeness)	Validation (conformance to specifications)
Planning Documents/Records			
1	Approved UFP-QAPP/Work Plans	**X**	
2	Contract	**X**	
4	Field SOPs	**X**	
5	Laboratory SOPs	**X**	
Field Records			
6	Field logbooks	**X**	**X**
7	Equipment calibration records	**X**	**X**
8	Chain-of-Custody Forms	**X**	**X**
9	Sampling diagrams/surveys, if needed	**X**	**X**
10	Drilling logs, if needed	**X**	**X**
11	Relevant Correspondence	**X**	**X**
12	Field audit reports, if needed.	**X**	**X**
13	Field corrective action reports	**X**	**X**
Analytical Data Package			
14	Cover sheet (laboratory identifying information)	**X**	**X**
15	Case narrative	**X**	**X**
16	Internal laboratory chain-of-custody	**X**	**X**
17	Sample receipt records	**X**	**X**
18	Sample chronology (i.e. dates and times of receipt, preparation, & analysis)	**X**	**X**
19	Communication records	**X**	**X**
20	LOD/LOQ establishment and verification	**X**	**X**
21	Standards Traceability	**X**	**X**
22	Instrument calibration records	**X**	**X**
23	Definition of laboratory qualifiers	**X**	**X**
24	Results reporting forms	**X**	**X**
25	QC sample results	**X**	**X**
26	Corrective action reports	**X**	**X**
27	Raw data (10%)	**X**	**X**
28	Electronic data deliverable (EDD)	**X**	**X**

Notes:
UFP-QAPP = Uniform Federal Program – Quality Assurance Program Plan
SOP = standard operating procedure
LOD = limit of detection
LOQ = limit of quantitation
QC = quality control

QAPP WORKSHEET #35: DATA VERIFICATION PROCEDURES

Data verification is a completeness check to confirm that all required activities were conducted, all specified records are present, and the contents of the records are complete. It applies to both field and laboratory records.

Verification Input	Description	Person(s) Responsible for Verification
Chain-of-Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed upon their completion and verified against the packed sample coolers. The chain-of-custody forms will be logged in at the laboratory and the project chemist will review sample log-in forms against field sample IDs. The original chain-of-custody is included in the cooler for shipment. Copies are retained in project files.	KGS field team KGS project chemist
Field Notebooks	Field notes and sampling logs will be reviewed weekly or at the end of a sampling event. Copies will be made and saved to the project drive.	KGS field team leader or designee
Field Sampling Logs	Verify that water level readings were measured for all planned sampling locations. Verify that low flow sampling parameters for groundwater wells met acceptance criteria.	KGS field team leader or designee
Field Corrective Actions	Verify that any required corrective actions were defined, implemented and effective.	KGS field team leader or designee
Analytical SOPs	Verify that the analytical SOPs were followed.	Laboratory Project Manager or QA Officer
Laboratory Data	Laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. Received data packages will be validated internally by KGS data validators.	Laboratory Project Manager or QA Officer Laurie Ekes/KGS
Method QC Results	Verify that the required QC samples were analyzed and met required limits.	Laboratory Project Manager or QA Officer Laurie Ekes/KGS
Field QC Sample Results	Verify that the required field QC samples were collected and analyzed and met required limits.	Laboratory Project Manager or QA Officer Laurie Ekes/KGS

QAPP WORKSHEET #35 – Continued

Verification Input	Description	Person(s) Responsible for Verification
Quantification Limits	Verify that the sample results met the project quantification limit specified in	Laurie Ekes/KGS
Laboratory Corrective Actions	Verify that applicable laboratory corrective actions were defined, implemented and effective.	Laboratory Project Manager or QA Officer Laurie Ekes/KGS

Notes:
SOP = standard operating procedure
QC = quality control
UFP-QAPP = Uniform Federal Program – Quality Assurance Program Plan

QAPP WORKSHEET #36: DATA VALIDATION PROCEDURES

The objective of the data validation is to assess the performance associated with the analysis in order to determine the quality of the data, which will be accomplished by evaluating whether the collected data comply with the project requirements and by comparing the collected data with criteria established based on the project DQOs.

All types of data, including screening data and definitive data, are relevant to the usability assessment. The following sections focus on the data review requirements for definitive data only. The analytical method quality control criteria used in data validation are defined in Worksheet #28 and are discussed below.

Data Review Requirements for Definitive Data

Scientifically sound data of known and documented quality that meet the DQOs are essential to the decision-making process. Data assessment includes verification, review, validation, evaluation and usability assessment. The data review process will be documented to facilitate efficient and accurate assessment of data quality and usability. The overall usability of the data is indicated with appropriate qualifiers.

Laboratory Requirements

The analytical data package must contain adequate information and be presented in a clear and concise manner. The laboratory data package should be organized such that the analytical results are reported on a per analytical batch basis, unless otherwise specified. A reviewer should be able to determine the PARCCS of the data, based on the information contained in the data package. Additional information may be required, depending on the detail of data review performed.

A schedule should be established so that data packages (Sample Delivery Groups) are provided in a timely manner to KGS for data review, validation, assessment, and use.

Laboratory Data Reporting Requirements

The following requirements should be met for reporting:

LODs, MDLs, and sample results should be reported to at least two significant figures, unless the appropriate number of significant figures for the measurement dictates otherwise.

Samples will be analyzed undiluted if possible. Non-detects will be reported to the LODs. If dilutions are necessary, associated reporting limits will be adjusted accordingly.

Manual Integrations

Manual integrations are an integral part of the chromatographic analysis process and will be done as warranted by the methodology. Examples of instances where manual integration would be warranted include, but are not limited to, co-eluting compounds resulting in poor-peak resolution, a misidentified peak, an incorrect retention time, or a problematic baseline. When manual integrations are used, the laboratory will follow their QC procedures. All manual integrations will include a complete audit trail and must be reviewed and approved by the laboratory section manager or QA officer. All manual integrations must be identified in case narratives.

Laboratory Data Review Requirements

All definitive data will be reviewed first by the laboratory analyst and then by the laboratory supervisor of the respective analytical section using the same criteria before they are submitted to KGS. This internal laboratory data review process, which is multi-tiered, should include all aspects of data generation, reduction, and QC assessment. Elements for review or verification at each level must include, but are not limited to, the following:

- Sample receipt procedures and conditions
- Sample preparation
- Appropriate SOPs and methodologies
- Accuracy and completeness of analytical results
- Correct interpretation of all raw data, including all manual integrations
- Appropriate application of QC samples and compliance with established control limits
- Documentation completeness
- Accuracy and completeness of data deliverables (hard copy and electronic)

Laboratory Data Evaluation

The calibration, QC, corrective actions, and flagging requirements for definitive data are provided in Worksheets #24 (Analytical Instrument Calibration) and #28 (Analytical Quality Control and Corrective Action). Data qualifiers should be applied by the laboratory as part of their internal validation activities. The data qualifiers for definitive data may be Q, E, J, M, B, D and/or U. The definitions of the data qualifiers are provided in Table 36-1. Flagging criteria apply when acceptance criteria are not met, and corrective actions were not successful or not performed. The data qualifiers must be reviewed by the supervisor of the respective analytical sections.

The KGS Project Chemist or designee will subsequently evaluate the flags applied by the laboratory as part of their data review and usability assessment activities.

Laboratory Method Blank Evaluation Guidance

For method blanks, the source of contamination should be investigated. If one-half the LOQ is exceeded, the laboratory should evaluate whether reprocessing of the samples is necessary using the following criteria: 1) the method blank contamination exceeds a concentration greater than 1/10 of the measured concentration of any sample in the associated preparation batch or 2) there is evidence indicating that the blank contamination otherwise affects the sample results. Except when the sample analysis resulted in a non-detect, all samples associated with method blank contamination must be reprocessed in a subsequent preparation batch. If insufficient sample volume remains for reprocessing, the results will be reported with a B-flag, along with any other appropriate data qualifier. If an analyte is found only in the method blank, but not in any batch samples, no flagging is necessary. Method blank contamination must be addressed in the case narrative.

Table #36-1

Laboratory Data Qualifiers

Qualifie	Description
Q	This indicates that one or more QC criteria fail. Data will be carefully assessed during data review with respect to the project-specific requirements and evaluated for usability.
J	The analyte was positively identified; reported results less than the LOQ are qualified as estimated.
B	The analyte was found in an associated blank above one half the LOQ, as well as in the sample.
U	The analyte was analyzed for but not detected.
M	The reported analyte result was calculated from a manually integrated compound.
D	The reported value is from a diluted sample result.
E	The reported analyte exceeds the calibration range of the instrument.

Data Verification Guidelines

The KGS Project Chemist will review the data verification performed by the laboratory for completeness and accuracy. Data verification may be done electronically or manually, or by a combination of both and is usually included during the data validation process. The verification process includes, but is not limited to the following:

- Sampling documentation (such as the chain-of-custody form)
- Preservation summary and holding times
- Presence of all analyses and analytes requested
- Use of required sample preparation and analysis procedures
- LODs and LOQs
- Correctness of concentration units
- Case narrative

Data Validation Guidelines

The data validation process builds on data verification. The KGS Project Chemist will review the laboratory case narrative and data validation results, with data qualifiers removed or added if needed.

Validation will be performed on an analytical batch basis by assessing QC samples and associated field sample results. Data validation guidelines have been developed according to the method requirements and general DoD requirements (Table 36-2). The criteria listed in QSM 5.1 Table B.15, the logic outlined in *National Functional Guidelines for Organic Superfund Methods Data Review* (USEPA, 2017) and the *DoD General Data Validation Guidelines* (EDQW, 2018) will be used to apply qualifiers to PFAS data. Where specific guidance was not available, the PFAS data will be evaluated in a conservative manner consistent with industry standards using professional experience.

The following information will be reviewed as part of a Level 2B-type summary data validation:

- Chain-of-custody documentation
- Holding time
- QC sample frequencies
- Method blanks
- LCS
- Surrogate spikes
- MS/MSD
- Initial and continuing calibration summary information
- Internal standards
- Tuning criteria
- Field duplicate precision
- Case narrative review and other method-specific criteria

Data flags, as well as the reason for each flag, will be applied to the data by the data validator/chemist after review of the data, as outlined above. The most conservative flag will be selected and entered into the database. A Data Validation Report will be prepared to summarize the findings and their impact on the overall data usability. This may be incorporated into the final usability assessment.

Raw Data Review, if needed

Data review can involve an in-depth review of the raw data to verify accuracy followed by analysis and interpretation of the data in the context of the project objectives and end-use as part of the usability assessment. The in-depth review may include but is not limited to the following:

- Method-specific instrument calibration and QC parameters
- Raw data and chromatograms
- System performance
- Proper integration (if applicable)
- Spectral matches, and/or RTs to verify analyte identification (where applicable)
- Random check of calculations
- Interference problems or system performance problems
- Estimated results (such as J-qualifiers)
- Resolution by the laboratory of any identified problems, as necessary

An automated process may be used, if available, to perform comparisons against quality control limits included in the laboratory EDDs. An automated process may include data flagging for issues related to method and field blanks, LCSs, MS/MSD samples, field duplicates, surrogate recoveries, and holding times.

Method Blank Evaluation Guidance

The KGS Project Chemist will evaluate laboratory B-qualified data such as method blanks, as well as other field blanks, based on the concentration of the analyte in the samples in relation to the concentration in the blank(s). The B-flag may be removed and not used if the analyte concentrations in the samples are much higher (≥5 times) than in the blank (≥10 times in case of common laboratory contaminants). Any blank contamination that may impact data usability will

be discussed in conjunction with project-specific goals. When a data set contains low-level detections in field samples and has associated field or laboratory blanks that have detections at similar concentrations, this suggests that the low-level detections in these field samples may be artifacts because of either field or laboratory practices. A sample detect that is ≤5 times the blank contamination (≤10 times for common laboratory contaminants) may be considered non-detect and flagged "U" at the detected concentration.

Duplicate Evaluation Guidance

QC measures for laboratory precision include laboratory duplicates, MS/MSDs, and surrogates. These measures will be evaluated by the laboratory and qualified according to applicable procedures, with the exception of the field duplicate samples.

Field Duplicate (FD) samples will be sent to the laboratory as blind samples and will be given unique sample identification numbers. FD sample results can be used to assess field sampling precision, laboratory precision, and, potentially, the representativeness of the matrix sampled. Field duplicate results will be evaluated and discussed in data review reports. In general, FD relative percent difference (RPD) precision should be ±30%.

Poor overall precision may be the result of one or more of the following: analytical measurement variation, poor sampling technique, sample transport problems, or spatial variation (heterogeneous sample matrices). If poor precision is indicated in both the field and analytical duplicates, then the laboratory may be the source of error. If poor precision is limited to the FD results, then the sampling technique, sample transport, and/or spatial variability may be the source of error.

Flagging Conventions

General data validation qualifiers are presented in Table 36-2. The allowable final data qualifiers for definitive data, listed in order of the most severe through the least severe, are X, J, UJ, and U. Their definitions are summarized in Table 36-3. Table 36-4 presents the final data reporting flag conventions to be used in compliance with the DoD QSM version 5.1.

Table 36-2
General Data Qualifying Conventions

QC Requirement	Criteria	Flag	Flag Applied To
Holding Time	Time exceeded for extraction or analysis by a factor of 2 or more	J for the positive results; X or UJ for NDs*	All analytes in the sample
Sample Preservation	Sample not preserved	J positive results; UJ for NDs*	Sample
	Temperature out of control	J for positive results; UJ for ND* Usability based on professional judgment	Sample

Table 36-2

General Data Qualifying Conventions - Continued

QC Requirement	Criteria	Flag	Flag Applied To
Instrument Tuning	Mass assignment error or Ion abundance method-specific criteria not met	X for all results, if critical ions involved, use judgment otherwise	All associated samples in analytical batch
Initial Calibration	All analytes must be within method-specified criteria (Worksheet #28)	J for positive results; UJ for ND, X based on professional judgment	All associated samples in analytical batch
Second Source Check or Continuing Calibration	All analytes must be within method-specified criteria (Worksheet #28)	High Bias: J for positive results, no flag for non-detects Low Bias: J for positive results, UJ for ND	All associated samples in analytical batch
LCS	%R greater than UCL %R less than LCL and greater than 10% %R less than LCL and less than 10%	J for the positive results J for the positive results; UJ for the ND J for the positive results; X for the ND	The specific analyte(s) in all samples in the associated analytical batch
Surrogate Spikes (IDA for PFAS analyses)	%R greater than UCL %R less than LCL and greater than 10% %R less than 10% Excessive dilution	J for positive results J for positive results; UJ for ND J for positive results; X for ND No flag required	Sample
Blanks (Method, and Field)	Analyte(s) detected greater than 1/2 LOQ (use the blank of the highest concentration)	U for positive sample results ≤5x highest blank concentration (10x for common laboratory contaminants)	All samples in preparation, field or analytical batch, whichever applies

Table 36-2

General Data Qualifying Conventions - Continued

QC Requirement	Criteria	Flag	Flag Applied To
Field duplicates or laboratory duplicates	Both sample results ≥5 times LOQ and RPD greater than 30% or One or both samples less than 5 times LOQ and a difference between results of ±2 times LOQ for water	J for the positive results J for the positive results UJ for ND	The specific analyte(s) in the native and FD sample Note: No flagging is required for RPDs based on J-flagged results
MS/MSD	%R greater than UCL %R less than LCL and >10% %R less than 10% or MS/MSD RPD greater than control limit; Sample concentration	J for positive results J for positive results; UJ for ND J for positive results; X for ND J for positive results	The specific analyte(s) in the parent sample
RT Window	Analyte within established window	X for all results	Sample

Key:

* = Based on analyte-specific review
LCL = lower confidence limit
LCS = laboratory control sample
LOQ = limit of quantitation
MS = matrix spike
MSD = matrix spike duplicate
IDA = Isotope Dilution Analytes
ND = not detected
QC = quality control
RPD = relative percent difference
RT = retention time
UCL = upper confidence limit
%R = percent recovery

Table 36-3

Usability Assessment Data Qualifiers

Qualifier	Description
X	**Analytical deficiency** – The sample results were affected by serious deficiencies in the ability to analyze the sample and meet method and project control criteria. Acceptance of rejection of the data shall be decided by the project team (including the project chemist). (DoD, 2018)
J	**Estimated** - The analyte was positively identified; the quantitation is an estimation because of discrepancies in meeting certain analyte-specific QC criteria or the analyte was positively identified but the associated concentration is an estimation above the DL and below the LOQ.
UJ	**Estimated non-detect** - The analyte was not detected; however, the result is estimated because of discrepancies in meeting certain analyte-specific QC criteria.
U	**Non-detect** - The analyte was analyzed for, but not detected or is qualified as non-detect because of blank contamination.

Key:
DL = detection limit
LOQ = limit of quantitation
QC = quality control

Table 36-4

Data Qualifying Conventions—Quantitation

Criteria	Report
< DL	Non-detect result: U at the LOD
≥ DL but ≤ LOQ	Estimated detected result; flagged J.
≥ LOQ	Report results, flag as needed.
≥ high standard/linear range	Estimated detected result; flagged J.

Examples:
DL = 2, LOD = 4, LOQ = 15, sample is undiluted.
Example #1: Analytical result: not detected; reported result: <4U.
Example #2: Analytical result: 3; reported result: 3J.
Example #3: Analytical result: 10; reported result: 10J.
Example #4: Analytical result: 15; reported result: 15

QAPP Worksheet #37: Data Usability Assessment

The data usability assessment is an evaluation based on the results of data verification and validation in the context of the overall project decisions or objectives. The assessment is used to determine whether the project execution and resulting data meet the project DQOs. Both the sampling and analytical activities must be considered, with the ultimate goal of assessing whether the final, qualified results support the decisions to be made with the data.

The following sections summarize the processes to determine whether the collected data are of the right type, quality, and quantity to support the environmental decision making for the project and describe how data quality issues will be addressed and how limitations of the use of the data will be handled.

Summary of Usability Assessment Processes

The KGS team will perform the data verification and validation procedures summarized in Worksheets #34 through #36 to evaluate sampling and laboratory compliance with the requirements with this QAPP and project planning documents. Evaluation activities will be documented in the data validation reports listed in Worksheet #33 and will be used to assess the usability of all project data in levels of detail ranging from an analyte- and sample-specific basis to the overall data set for the sampling event.

Evaluative Procedures to Assess Project-Specific Overall Measurement Error

The assessment will include an evaluation of the QC elements relating to precision, accuracy, representativeness, comparability, completeness (both sample collection and analytical), and sensitivity (PARCCS). In-depth assessment will be performed during the data review and validation processes to assess conformance with the field SOPs, laboratory SOPs, and objectives of this document. Qualifiers will be used to indicate overall usability of the data.

Personnel Responsible for Performing Usability Assessment

Laurie Ekes/KGS Project Chemist
Katherine Thomas/James Ropp/KGS PM

Usability Assessment Documentation

The results will be assembled and reported for an overall quality assessment in data validation reports. The data validation reports will identify precision and accuracy exceedances with respect to the laboratory performance for each batch of samples, as well as comparability of field and laboratory duplicates. An overall assessment of the impact of data usability issues will be presented in the project report. The usability assessment of the PFAS investigative data will be used to determine whether the data meets the intended goals of the project tasks as outlined in Worksheets #10 and #17. Usability discussion will cover PARCCS criteria as described in the following subsections.

Precision

Precision is the measure of variability between individual sample measurements under prescribed conditions. Precision can be assessed by replicate measurements of known laboratory standards and by analysis of duplicate environmental samples (spiked or unspiked). Precision is determined by analysis of field duplicate samples, laboratory duplicates, and/or MSDs. Field duplicate samples, laboratory duplicate samples and MSD samples should be analyzed to assess field and

laboratory precision at a frequency as described in Worksheet #20 (Field QC Sample Summary). The required levels of precision for each method, matrix, and analyte are provided in Worksheet #15 (Reference Limits and Evaluation). For duplicate sample results, the precision is evaluated using the Relative Percent Difference (RPD). The formula for calculating RPD is:

$$RPD = [|C_1 - C_2|/(\text{average of } C_1 + C_2)] \times 100$$

where:

C_1 = first sample value (original sample or MS value);

C_2 = second sample value (duplicate sample or MSD value).

Accuracy

Accuracy is the degree of agreement of a measurement to an accepted reference or true value. An evaluation of the accuracy of a measurement system provides an estimate of measurement bias. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within acceptable limits. Analytical accuracy is measured by comparing the percent recovery (%R) of analytes spiked into an LCS or MS to control limits. Surrogate compound recoveries also are used to assess accuracy and method performance for organic analyses. Accuracy requirements are listed for each method, matrix, and analyte in Worksheet #15 (Reference Limits and Evaluation). The formula for calculating %R is:

$$\%R = [(S-U)/C] \times 100$$

where:

S = measured concentration of spiked aliquot;

U = measured concentration of unspiked aliquot (zero for LCS, surrogates and cal standards);

C = actual concentration of spike.

Representativeness

Representativeness is a qualitative term that refers to the degree in which data accurately and precisely depicts the characteristics of a population, whether referring to the distribution of contaminant within a sample, a sample within a matrix, or the distribution of a contaminant at a site. Representativeness is determined by appropriate program design, with consideration of elements such as sampling locations. Objectives for representativeness are defined for each sampling and analysis task and are a function of the investigative objectives. Assessment of representativeness will be achieved through use of the standard field sampling and analytical procedures. Decisions regarding sample locations and numbers and the sampling design(s) are documented in Worksheets #10 (Conceptual Site Model), #11 (Data Quality Objectives), and #17 (Sampling Design and Rationale).

Comparability

Comparability is a qualitative indicator of the confidence with which one data set can be compared to another data set. The objective is to produce data with the greatest possible degree of comparability. Comparability is achieved by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard reporting formats.

Completeness

Completeness is a measure of the amount of valid data obtained compared with the amount that was expected to be obtained under normal conditions. It is calculated for the aggregation of data for any particular sampling event as set out in the DQOs. Valid data are data that are usable in the context of the project goals. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. The goal for completeness is 95 percent for all samples.

Sensitivity

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. It is important to be able to detect the target analytes at the levels of interest. Sensitivity requirements include the establishment of various limits such as calibration requirements, instrument LODs, and LOQs. The project QA/QC and method requirements have been established to be compliant with the DoD QSM Version 5.1 (DoD, 2017). Project-specific LOD and LOQs are established in Worksheet #15 to meet the DQOs in Worksheet #11.

REFERENCES

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ATTACHMENT A
Field Standard Operating Procedures

KOMAN Government Solutions, LLC	STANDARD OPERATING PROCEDURE	Number SOP-F001	Page 1 of 9
		Effective Date 8/15/2017	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Ericka Seiler	
Subject: **MONITORING EQUIPMENT CALIBRATION**		Approved by: Stephen Deeter	

TABLE OF CONTENTS

1.0 PURPOSE

A Water Quality Meter (WQM) (e.g., YSI 600XL, or equivalent) is used to obtain measurements of temperature, pH, dissolved oxygen (DO), conductivity/specific conductance, turbidity, and oxidation-reduction potential (ORP). Review the operation manual before using any instrument.

2.0 SCOPE AND APPLICABILITY

Typically, the WQM will be calibrated [initial calibration (ICAL)] at the start of each sampling day and as needed during the course of the day. Some projects also require the WQM to be calibration checked periodically throughout the day [continuing calibration verification (CCV)]. Please refer to the project-specific sampling and analysis plan.

In the event any instrument fails to calibrate and/or operate properly, it will be either diagnosed and repaired in the field (if possible) or a replacement instrument procured. Personnel will also compare readings with expected and/or historic measurements throughout the instrument's use to ensure the instrument is operating properly (e.g., DO cannot be negative, a pH of 13 for groundwater is suspect, etc.).

3.0 PROCEDURES

To obtain correct measurement, it is necessary to calibrate the sensor using the standard solution before performing measurement. It is preferable to conduct instrument calibrations in a controlled environment (i.e., an area, such as an indoor room, designated for calibration efforts that is unlikely to be affected by external factors like weather).

In general, to start operation, make sure the sensor is connected to the instrument properly and press the POWER key. The user should allow the instrument a short period to equilibrate to its environment (i.e., "warm up"). This period can be estimated by watching the instrument drift upon start up. Once the instrument drifting slows or stops, the instrument can be assumed ready for calibration. In the event the WQM fails any of the following calibration procedures, the manufacturer should be consulted and/or the defective WQM replaced.

3.1 TEMPERATURE

Most instrument manuals state that daily calibration of the temperature sensor is not required, but this SOP provides steps for checking the accuracy of the temperature sensor. This accuracy check is performed at least once per year and the accuracy check date/information is kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was performed over a year prior to the date of use, it is recommended that the temperature sensor accuracy be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor must be checked.

3.1.1 Verification Procedure

1. Allow a container filled with water to equilibrate to ambient temperature.
2. Place a National Institute of Standards and Technology (NIST) - traceable thermometer and the instrument's temperature sensor into the water and wait approximately five minutes for both temperature readings to stabilize.
3. Compare the two measurements. The instrument's temperature sensor must agree with the NIST-traceable thermometer measurement within the accuracy of the sensor (usually ±0.2ºC). If the measurements do not agree, the instrument may not be calibrated properly

and/or may not be working properly and the manufacturer should be consulted and/or the defective WQM replaced.

3.2 DISSOLVED OXYGEN

DO is the volume of oxygen that is dissolved in water and is measured using a membrane-covered electrode.

The DO probe's membrane and electrolyte solution should be periodically replaced. If the sampler cannot verify when the DO probe was last serviced, the membrane and electrolyte solution will be replaced prior to the sampling period. Failure to perform this step may lead to erratic or erroneous measurements.

3.2.1 Calibration Procedure

1. Gently dry the temperature sensor according to manufacturer's instructions.
2. Place a sponge or paper towel, wetted with water, on the bottom of the DO calibration container that comes with the instrument.
3. Place the DO probe in the container without the probe coming in contact with the wet sponge or paper towel. The probe must fit loosely in the container to ensure it is vented to the atmosphere.
4. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). During this time, turn-on the instrument to allow the DO probe to warm-up. Select monitoring/run mode and check temperature readings. Readings must stabilize before continuing to the next step.
5. Select calibration mode; then select "DO%."
6. Enter the local barometric pressure [usually in millimeter (mm) of mercury (Hg) (mmHg)] for the sampling location into the instrument. This measurement can be determined from an on-site barometer or from the instrument itself if equipped. Do not use barometric pressure obtained from the local weather services unless the pressure is corrected for the elevation of the sampling location and unless this is the only source of barometric data. (Note: inches of Hg times 25.4 mm/inch equals mmHg).
7. The instrument should indicate that the calibration is in progress. After calibration, the instrument should display percent saturated DO. Check the reading against the Temperature/Atmospheric Pressure (Table A, Attachment A). For example, if the barometric pressure is 752 mm Hg or the instrument is at an elevation of 278 feet, the percent saturation value after calibration should be 99%.
8. While the probe is still in the calibration cup, select monitoring/run mode. Compare the DO mg/L reading to the Oxygen Solubility at Indicated Pressure (Table B, Attachment A). For example, if the barometric pressure is 760 mm Hg and the temperature inside the calibration cup is 20ºC, the DO milligrams per Liter (mg/L) reading should be 9.09 mg/L. If they do not agree to the accuracy of the instrument (usually ±0.2 mg/L), repeat calibration. If this does not work, change the membrane and electrolyte solution and repeat calibration.
9. Remove the probe from the container, rinse it with distilled water, pat it dry with a towel, and place it into a fresh 0.0 mg/L DO solution standard. The standard must be filled to

the top of its container and the DO probe must fit tightly into the standard's container (i.e., no headspace). Check the temperature readings, they must stabilize before continuing.

10. Wait until the "mg/L DO" readings have stabilized. The instrument should read <0.5 mg/L or to the accuracy of the instrument (usually ±0.2 mg/L) within 30 seconds. If the instrument cannot reach this value, it will be necessary to clean the probe, and change the membrane and electrolyte solution. If this does not work, prepare a new 0.0 mg/L standard. If these measures do not work, the manufacturer should be consulted and/or the defective WQM replaced.
11. After calibration is complete, rinse the probe with deionized water, removing the calibration solution.
12. Record the calibration information in the field calibration sheet for the WQM.

3.3 pH (ELECTROMETRIC)

The pH is the measure of the degree of the acidity or alkalinity of a solution as measured on a scale of 0 to 14 standard units (SU). The pH of a sample is determined electrometrically using a glass electrode. All pH measurements are in SUs.

Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. For ground water, the pH will usually be close to seven. Three standards are needed for the calibration: one close to seven, one at least two pH units below seven and the other at least two pH units above seven (typically 4.0, 7.0, and 10.0). For those instruments that will not accept three standards, the instrument will need to be re-calibrated if the water sample's pH is outside the range defined by the two standards used in the initial calibration.

3.3.1 Calibration Procedure

1. Allow the buffered standards to equilibrate to the ambient temperature.
2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor.
3. Remove the cover of the probe, rinse in a cup filled with deionized water or use a spray bottle, and remove the excess water from the probe.
4. Select monitoring/run mode. Immerse probe in the initial buffered standard (e.g., pH 7) and allow at least one (1) minute for temperature equilibration before proceeding.
5. Enter the buffered standard value (e.g., pH 7) into the pH calibration menu of the instrument. Allow the pH reading to stabilize for approximately 30 seconds and if the reading does not change, finish the calibration. The reading should remain within the manufacturer's specifications; if it changes, recalibrate. If readings continue to fluctuate or readings do not stabilize after recalibration, the manufacturer should be consulted and/or the defective WQM replaced.
6. Remove probe from the initial buffered standard, rinse in a cup filled with deionized water or use a spray bottle, and remove the excess water from the probe.
7. Immerse probe into the second buffered standard (e.g., pH 4). Repeat step 5, substituting "4" into the pH calibration menu instead of "7."

8. Remove probe from the second buffered standard, rinse in a cup filled with distilled water or use a spray bottle, and blot dry with soft tissue. If the instrument only accepts two standards the calibration is complete, proceed to step 11. Otherwise continue with step 9.
9. Immerse probe in third buffered standard (e.g., pH 10). Repeat step 5, substituting "10" into the pH calibration menu instead of "7."
10. Remove probe from the third buffer standard, rinse in a cup filled with distilled water or use a spray bottle, and blot dry with soft tissue.
11. Select monitoring/run mode, if not already selected. To ensure that the initial buffered calibration standard (e.g., pH 7) has not changed, immerse the probe into the initial standard. Wait for the reading to stabilize. The reading should read the initial standard value (e.g., 7) within the manufacturer's specifications. If not, re-calibrate the instrument. If re-calibration does not help, the calibration range may be too great. Reduce calibration range by using standards that are closer together. If these measures do not work, the manufacturer should be consulted and/or the defective WQM replaced.
12. Record the calibration information in the field calibration sheet for the WQM.

3.4 SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to conduct an electrical current. Specific conductance is the conductivity value corrected to 25ºC. Calibrating an instrument for specific conductance automatically calibrates the instrument for conductivity, and vice-versa.

Most instruments are calibrated against a single standard which is near to, but below, the specific conductance of the environmental samples. A second standard, which is above the environmental sample specific conductance, is sometimes used to check the linearity of the instrument in the range of measurements.

3.4.1 Calibration Procedure

1. Allow the calibration standard to equilibrate to the ambient temperature.
2. Remove probe from its standard container, rinse the probe with deionized water or a small amount of the conductivity/specific conductance standard (discard the rinsate), and place the probe into the conductivity/specific conductance standard. Gently move the probe up and down in the solution to remove any air bubbles from the sensor. Allow the probe to sit in the solution for at least one (1) minute for temperature equilibration before proceeding.
3. Select calibration mode and select "Specific Conductance" from the calibration menu. Enter the calibration value of the solution [milliSiemens per centimeter (mS/cm) at 25ºC] and continue. Allow the specific conductance reading to stabilize for approximately 30 seconds and finish the calibration. The reading should remain within manufacturer's specifications. If it does not, recalibrate. If readings continue to change after recalibration, the manufacturer should be consulted and/or the defective WQM replaced.

- Remove probe from the standard, rinse the probe with a small amount of the second conductivity/specific conductance standard (discard the rinsate), and place the probe into the second conductivity/specific conductance standard. The second standard (used when

applicable) will serve to verify the linearity of the instrument. Read the specific conductance value from the instrument and compare the value to the specific conductance on the standard. The two values should agree within the specifications of the instrument. If they do not agree, re-calibrate. If readings do not compare after recalibration, then the second standard may be outside the linear range of the instrument. Use a standard that is closer to, but above, the first standard and repeat the verification. If these measures do not work, the manufacturer should be consulted and/or the defective WQM replaced.

- Record the calibration information in the field calibration sheet for the WQM.

NOTE: These procedures should only be used for instruments that are capable of automatically correcting specific conductance for temperature (to 25ºC). For instruments that cannot calibrate for specific conductance, follow the procedures in the instrument's manual for conductivity calibration. If calibrating for conductivity instead of specific conductance, the solutions conductivity value must be corrected for the temperature that the sensor is reading.

3.5 OXIDATION-REDUCTION POTENTIAL

The ORP is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolt (mV) and is temperature dependent.

3.5.1 Calibration or Verification Procedure

1. Allow the calibration standard (a Zobell Solution) to equilibrate to ambient temperature.
2. Remove the cover of the probe and place it into the standard.
3. Select monitoring/run mode.
4. While stirring the standard, wait for the probe temperature to stabilize, and then read the temperature.
5. Look up the mV value at this temperature from the mV versus temperature correction table found in Table C (Attachment A). It may be necessary to interpolate mV values between temperatures. Select "calibration mode," then "ORP." Enter the temperature-corrected ORP value and calibrate the instrument.
6. Select monitoring/run mode. The reading should remain unchanged within manufacturer's specifications. If it changes, re-calibrate. If these measures do not work, the manufacturer should be consulted and/or the defective WQM replaced.
7. If the instrument instruction manual states the instrument is factory calibrated, then verify the factory calibration against the standard. If reading does not agree within the specification of the instrument, the instrument will need to be re-calibrated by the manufacturer.
8. If calibration is successful record the calibration information in the field calibration sheet for the WQM.

3.6 TURBIDITY

Turbidity is measured using a separate instrument (e.g., LaMotte 2020, or equivalent) because turbidity cannot be measured accurately in a flow-through cell.

Turbidity refers to clarity of the water sample and is a measure of relative sample clarity. The greater the amount of total suspended solids in the water, the higher the measured turbidity. The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidity meter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source.

Some instruments will only accept one standard. For these instruments, the standards will serve as check points.

3.6.1 Calibration Procedures

1. If the standard cuvette is not sealed, rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe the inside of the cuvette because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.
2. Before performing the calibration procedure, make sure the cuvettes are not scratched and that the outside surfaces are dry and free from fingerprints and dust. If the cuvette is scratched or dirty, discard and/or clean the cuvette, respectively.
3. Zero the instrument by using either a zero or 0.02 Nephelometric Turbidity Unit (NTU) standard. A zero standard (approximately 0 NTU) can be prepared by passing distilled water through a 0.45 micron pore size membrane filter.
4. Using a standard at 1 NTU, calibrate according to manufacturer's instructions or verify calibration if instrument will not accept a second standard. If verifying, the instrument should read the standard value to within the specifications of the instrument. If the instrument has a range of scales, check each range that will be used during the sampling event with a standard that falls within the range.
5. Using a standard at 10 NTU, calibrate according to manufacturer's instruction or verify calibration if instrument does not accept a third standard. If verifying, the instrument should read the standard value to within the specifications of the instrument.
6. Record the calibration information in the field calibration sheet for the WQM.

Note: If only performing a two-point calibration (depending on project requirements), the 0.02 NTU and 10 NTU standard should be used.

4.0 POST CALIBRATION CHECK

After the initial field calibration is performed, the field instrument's parameter values may drift throughout the work day. Making it import to determine the amount of instrument drift that has occurred during the work day by comparing current standard solution readings with the initial calibrated values of that work day. The comparison is performed by placing the field instrument in measurement mode (not calibration mode) and placing the probe in one or more of the

parameter standards used during the initial calibration; for turbidity place the NTU standard cuvette into the turbidimeter. Wait for the instrument to stabilize and record the measurement in the PM portion of the field calibration sheet. Compare the PM measured value to the initial calibrated value. The value difference is then compared to the drift criteria or post calibration criteria described in the projects quality assurance project plan (QAPP) or the sampling and analysis plan. If the checked value is outside the criteria, then the measurement data taken that day will need to be qualified.

For post calibration check of dissolved oxygen, follow the calibration instructions steps one through three listed in section 3.2.1 but keep the instrument is in measurement mode. Record dissolved oxygen value (mg/L), temperature, and barometric pressure. Compare the measurement value to the values present in the Table B (Attachment A). The values should be within the criteria specified for the project. If checked value drifted outside the criteria, then the measurement data taken that day will need to be qualified.

If the quality assurance project plan or the sampling and analysis plan do not list the drift criteria or the post-calibration criteria, use the criteria listed in the table below.

Measurement	**Post Calibration Criteria**
Dissolved Oxygen	± 0.5 mg/L of saturated value* < 0.5 mg/L for the 0 mg/L solution, but not a negative value
Specific Conductance	±5% of standard or ± 10 µS/cm (whichever is greater)
pH	± 0.3 pH unit with pH 7 buffer*
Turbidity	± 5% of NTU standard
ORP	± 10 mv*

Note: * Table 8.1, USEPA Region 1 YSI 6-Series Sondes and Data Logger SOP, January 27, 2016, revision 13.

Post calibration criteria for field parameter values will be included on the field calibration sheets for quick reference.

5.0 DATA MANAGEMENT AND RECORDS MANAGMENT

All calibration records must be documented in either the project field book or field calibration sheet. Documented calibration information must include the instrument manufacturer, instrument make/model number, instrument identification, the standards solutions used to calibrate the instruments (including solution source), the calibration date, the instrument readings, the post calibration check, and the name of the field personal who performed the calibration. Examples of field calibration sheets are included in Appendix A.

6.0 REFERENCES

2017, Quality Assurance Unit U.S. Environmental Protection Agency – Region 1 Standard Operating Procedure Calibration of Field Instruments, March 2017.

2012, YSI. User Manual, 6-Series Multiparameter Water Quality Sondes. Yellow Springs Instruments (YSI), Incorporated. March 2012. Phone (800) 765-4974.

2012, Lamotte. User Manual, Lamotte 2020we/wi Tubidimeter. Lamotte Company. 1 February 2012. Phone: (410) 778-3100.

Attachment A

Tables

Table A

a xylem brand

CALIBRATION TABLE

Calibration Values for Various Atmospheric Pressures and Altitudes

Pressure			Altitude		Calibration Value
Inches Hg	mm Hg	kPa	Feet	Meters	Percent Saturation
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
28.43	722	96.3	1413	431	95
28.11	714	95.2	1703	519	94
27.83	707	94.2	1995	608	93
27.52	699	93.2	2290	698	92
27.24	692	92.2	2587	789	91
26.93	684	91.2	2887	880	90
26.61	676	90.2	3190	972	89
26.34	669	89.2	3496	1066	88
26.02	661	88.2	3804	1160	87
25.75	654	87.1	4115	1254	86
25.43	646	86.1	4430	1350	85
25.12	638	85.1	4747	1447	84
24.84	631	84.1	5067	1544	83
24.53	623	83.1	5391	1643	82
24.25	616	82.1	5717	1743	81
23.94	608	81.1	6047	1843	80
23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
22.76	578	77.0	7401	2256	76
22.44	570	76.0	7749	2362	75
22.13	562	75.0	8100	2469	74
21.85	555	74.0	8455	2577	73
21.54	547	73.0	8815	2687	72
21.26	540	71.9	9178	2797	71
20.94	532	70.9	9545	2909	70
20.63	524	69.9	9917	3023	69
20.35	517	68.9	10293	3137	68
20.04	509	67.9	10673	3253	67
19.76	502	66.9	11058	3371	66

Table B

OXYGEN SOLUBILITY TABLE

a xylem brand

Solubility of Oxygen (mg/L) in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.

Temp °C	Chlorinity 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	3.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

Table C
ORP versus Temperature

Temperature, C	Zobell Solution Value, mV vs. Ag/AgCl (4 M KCl)
-5	267.0
0	260.5
5	254.0
10	247.5
15	241.0
20	234.5
25	228.0
30	221.5
35	215.0
40	208.5
45	202.0
50	195.5

Attachment B

Calibration Logs

Field Instrument Calibration Log

Date: _____ **Weather:** _____

Project/Site Name: _____ **Instrument:** _____

Calibrated By: _____ **Serial Number:** _____

Parameters	Solution Expiration Date	Morning Calibration Time _____		Cal. Temperature °C	Afternoon Calibration Time _____		Cal. Temperature °C
Specific Conductivity (1.413 µS/cm[c])							
pH (7)							
pH (4)							
pH (10)							
ORP (240 mv)							
Dissolved Oxygen (%)							
Dissolved Oxygen (mg/L)							
Barometric Pressure (mmHg)							
Notes:							

Signature: _____ **Date:** _____

Turbidity Instrument Calibration Log

Project/Site Name: _____ **Instrument:** _____

Calibrated By: _____ **Serial Number:** _____

Date	Pre-Cal 0 NTU AM	Pre-Cal 0 NTU AM	Post-Cal 10 NTU AM	Post-Cal 10 NTU AM	Pre-Cal 0 NTU PM	Pre-Cal 0 NTU PM	Post-Cal 10 NTU PM	Post-Cal 10 NTU PM

Signature: _____ **Date:** _____

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		Effective Date 8/15/2017	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Ericka Seiler	
Subject: **EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT**		Approved by: Stephen Deeter	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels and light non-aqueous phase liquid (LNAPL).

2.0 SCOPE AND APPLICABILITY

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 PROJECT PLANNING

Accurate, valid, and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project objectives.
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To ensure that these conditions are met, adequate descriptions of subsurface geology, well construction methods, and well analytical results must be available. The following steps will help to ensure that the required data are collected that will be used to assess the usability of existing monitoring wells for collection of samples.

3.1 PRELIMINARY EVALUATION

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan and/or report for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number, and location as reference by coordinates, distance from prominent site features, and/or location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The soil profile and stratigraphy.
- The borehole depth and diameter.

- The depth to bedrock – where the rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.
- The evaluation of the type of protective casing (i.e., flush-mounted or stick-up), top of the protective casing, the top of the well riser, and the ground surface.

3.2 FIELD INSPECTION

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing (including type), cap, and lock.
- The condition of the cement seal surrounding the protective casing (if visible).
- The presence of depressions or standing water around the casing.
- The presence of, and condition of, dedicated sampling equipment.
- The presence of a reference mark/point (e.g., a notch) on the inner well casing.

If the protective casing, cap, and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, the infiltration of surface water into the well may have occurred. This can cause previous sampling results to be suspect, unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may cause previously-collected water quality data to be suspect. If the monitoring well is to be used in the future, deficiencies identified in the steps described above should be rectified to rehabilitate the well.

Don personal protective equipment, as required. After disconnecting any wires, cables, or electrical sources, remove the lock. If required by the health and safety plan and the health and safety manager, use a photo-ionization detector (PID) or a flame ionization detector (FID) to check the area around the well for VOC vapors (background reading). Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened. If the use of a PID or FID is indicated, uncap the well and immediately place the PID or FID in the vicinity of the wellhead to monitor organic vapor concentration. Wellhead PID or FID results are used to determine relative contamination and should not be used to make health and safety determinations. Breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. The following information should be noted:

- Cap function.

- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of water between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser (well) cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment (if directed by the project manager/task manager) and inspect size, materials of construction, and condition (if not previously identified).

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth, and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted).

Lastly, as a final step, the location, condition, and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation. All observations shall be recorded in the site geologist/hydrogeologist's field notebook or on the Monitoring Well Evaluation Form (Attachment A).

3.3 WATER LEVEL (HYDRAULIC HEAD) MEASUREMENTS

3.3.1 General

Groundwater level measurements can be made in monitoring wells, private, or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging and/or sampling.

All groundwater level measurements shall be made to the nearest 0.01 feet, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Form (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded to verify the correct location is being measured. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a reference point (e.g., a notch or other prominent marking) on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum can also be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (e.g., chalked-line, electrical, etc.). Oil layers may also cause problems in determining the true water level in a well. Special devices (i.e., oil-water interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in

conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements, from a group of wells used to develop a groundwater contour map, shall be made in the shortest practical time to minimize affects due to weather changes and/or tidal influence (if present).

3.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electric water level indicator methods have been found to be best, and thus should be utilized whenever possible when precision is required (e.g., synoptic water level measurements for defining potentiometric surfaces). Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided when precision is required, but may be suitable when used to establish approximate water depths for purging and sampling purposes. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer (e.g., In-Situ® Troll).

3.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Don personal protective equipment, as required.
2. If required by the health and safety plan and the health and safety manager, use a PID or a FID to check the area around the well for VOC vapors (background reading).
3. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.
4. If the use of a PID or FID is indicated, uncap the well and immediately place the PID of FID in the vicinity of the wellhead to monitor organic vapor concentration. Wellhead PID or FID results are used to determine relative contamination and should not be used to make health and safety determinations. Breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection.
5. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Form (Attachment B):
    - Well number.
    - Water level (to the nearest 0.01 feet). Water levels shall be taken from the reference point (e.g., notch) on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to

stabilize.

- Time and day of the measurement.
- Thickness of LNAPL, if present.
- Visual or olfactory evidence of contamination such as a gasoline odor, sheen, or presence of sludge/LNAPL.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well casing.

3.3.4 Water Level Measuring Devices

Electric Water Level and Oil/Water Interface Indicators

Electric water level indicators are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric water level indicators available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, and/or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the reference point on the inner well casing. The electric tape is read (to the nearest 0.01 feet) at the measuring point and recorded where contact with the water surface was indicated.

For oil-water interface probes, the presence of LNAPL is indicated by a steady light and tone response from the oil-water interface probe while the presence of water is indicated by an intermittent light and tone response.

Note: If the electric water level indicator is to be used for measuring total well depth, verify the indicator is waterproof before lowering into the water column. Water level indicators are available that utilize probes that are not waterproof.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recording device (e.g., a hand-held datalogger or laptop personal computer) at the surface to record

changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a personal computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 feet accuracy.

Note: Pressure transducers are available in varying pressure/depth capabilities and differing cable lengths. Verify the depth capability of the transducer in relation to the depth of the well to be monitored as using a shallow pressure transducer with a deep/thick water column can produce unreliable data and/or damage the transducer.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

3.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Form (Attachment B). All water level measurements shall be measured from the reference point. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

3.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. See Section 3.4 regarding decontamination of water level measuring equipment.

Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 feet accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

3.4 EQUIPMENT DECONTAMINATION

All portions of a device which projects down the well casing must be decontaminated prior to advancing to the next well. Manufacturer's instructions for equipment decontamination should be followed. Variations from the manufacturer's requirements may be implemented based on the project objectives, but they must be defined prior to conducting any field activities. Consult the project planning documents and Decontamination of Field Equipment SOP.

3.5 HEALTH AND SAFETY CONSIDERATIONS

All field staff are required to follow the site-specific health and safety plan (SSHSP) developed

for individual project sites prior to initiating site activities. The SSHSP will identify the site contaminants of concern and will also outline the personal protective equipment and air monitoring requirements that is appropriate for the expected project and site tasks.

At sites with known or suspected volatile organic contaminants, groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. The use of a PID or a FID is recommended for sites with known or suspected volatile organic contaminants. If required per the SSHSP and project sampling and analysis plan, initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed. Breathing zones concentrations will be used to determine required levels of protection. Under certain conditions, airtight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

3.6 RECORDS

A record of all field procedures, tests, and observations must be recorded in the site logbook, designated field notebook, or the field log sheets. Entries in the log/notebook/sheet should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

4.0 REFERENCES

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Solinst, 2002. Interface Meter Operating Instructions, Model 122. Solinst Canada Ltd. October 2002. www.solinst.com . Phone (800) 661-2023

Attachment A

Monitoring Well Evaluation Form

Well Evaluation Form	
Project Name:	**Date:**
Location:	**Time:**
Tidally Influenced (yes/no):	**Field Crew:**

Field Measurements				
Well ID	**PID Reading (PPM)**	**Depth to Water (feet)**	**Total Well Depth (feet)**	**Comments**

Well Construction Details		
Total Depth (ft)	**Ground Elevation**	**Screened Interval**

Checklist	
Well Material and Diameter:	
Well Casing Reference Point:	
Well ID Tag Present?	
Well Secured?	
Photo Taken?	

Well Condition	
Protective Cover:	
Well Riser Casing:	
Well Pad:	
Other (Posts, Tags, Paint, etc.):	
Standing Water Around Well?	
Dedicated Equipment Present?	
Sediment in Well:	

Attachment B

Groundwater Level Measurement Form

Groundwater Level Measurement Form

Project Name:	**Date:**
Location:	**Weather:**
Water Level Meter:	**Field Crew:**

Well ID	Time	Depth to Water (feet below TOC)	Total Well Depth (feet below TOC)	Notes

Comments:

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		Effective Date 6/18/2018	Revision 1
		Applicability KOMAN Government Solutions	
		Prepared by: Ericka Seiler	
Subject: **GROUNDWATER SAMPLING**		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide a standardized set of procedures, decisions, and criteria for groundwater sampling. Proper collection procedures are necessary to assure the quality and integrity of all groundwater samples. Additional site and/or area specific procedures and requirements will be provided in the project work plans, as necessary.

Groundwater sampling can be accomplished using wide range of sampling techniques, such as standard (volumetric) sampling, low-flow, Passive Diffusion Bag (PDB), Regenerated Cellulose Dialysis Membrane (RCDM), and extraction well sampling.

2.0 SCOPE AND APPLICABILITY

The procedures described herein are applicable to all existing monitoring wells and extraction wells, and, for the most part, are independent of construction materials and methods. The selection of the appropriate groundwater sampling technique for each monitoring well or groups of monitoring wells will be based on site-specific conditions in addition to the technical project requirements described in the approved project planning documents.

3.0 STANDARD/VOLUMETRIC GROUNDWATER SAMPLING

Groundwater samples collected from monitoring wells using standard/volumetric techniques will follow the steps summarized below.

- The site-specific project plans should be consulted to determine the sampling depth intervals. If sampling intervals have not been predetermined (i.e., stated in the project plans), the following guidance will be followed. For screened monitoring wells, a submersible pump is typically to a depth 3 to 5 feet above the bottom of the well screen. For open bedrock monitoring wells, a submersible pump is typically lowered half-way down the open borehole interval of each well.
- Insert the measurement probes into the flow-through cell. The purged groundwater is directed through the cell, allowing measurements to be collected before the water contacts the atmosphere.
- The initial field parameters of pH, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), turbidity, and temperature of water are measured and recorded in the field logbook and/or sampling forms (Attachment A).
- Purge the well for, typically, a minimum of three and a maximum of five well volumes, while collecting field measurements of pH, specific conductance, DO, ORP, turbidity, and temperature at 5- to 10-minute intervals. Stabilization of the field parameters within ±10 percent (%) will be the criterion for termination of purging operations after reaching the project designated maximum well volume. The project-specific planning documents will identify the specific requirements for termination of the purging operations if the field parameters do not stabilize within a reasonable period of time and/or volume.
- The pumping rate for well purging should be low enough that the groundwater level in the well is not drawn down more than one-third of the total water column in the well, if possible. If the monitoring well is not capable of at least 1 gallon per minute (gpm)

sustained yield, the well should be pumped dry and sampled after the well recovers to at least 75 percent of the initial water column.

- Once purging has been completed, the flow-through cell is removed, and samples are collected directly from the discharge hose.
- Preserve the samples according to the analytical method (or collect the sample directly into pre-preserved bottles) and store the samples at 4 degrees Centigrade (°C) (+/- 2°C) prior to shipping in accordance with standard sampling protocol.
- Sample fractions for volatile organic compounds (VOCs) are normally collected first and directly into pre-preserved sample containers.

4.0 LOW-FLOW GROUNDWATER SAMPLING

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to commence. Achievement of turbidity levels of less than 5 Nephelometric Turbity Units (NTU) and stable draw-downs of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this SOP are met. If after four hours of purging, indicator field parameters have not stabilized and the minimum purge volume requirements have not been met, one of the following three courses of action may be taken:

a) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analyses, may not meet the sampling objectives);

b) continue purging until stabilization is achieved or the minimum purge volume has been removed; or

c) discontinue purging, do not collect any samples, and record in the field logbook and/or sampling forms (Attachment A) that stabilization could not be achieved (documentation must describe attempts to achieve stabilization).

Note that the longer purging continues prior to sampling, the more likely it is that the groundwater sample does not represent groundwater conditions in the immediate vicinity of the well (e.g., the sample will average groundwater conditions over a greater distance from the well). Hence, based on the objectives of the sampling program, the hydraulic conductivity of the formation, and spacing of the wells, prolonged purging sessions may not be appropriate.

Low-flow sampling is implemented in the following manner.

- Measure the water level and record this datum on the field form.
- Measure the total well depth, and record on the field form. Note: Measuring total well depth may disturb the water column, and therefore it is recommended that total depth be measured the day before purging and sampling, or after sampling the well.
- Calculate the length of the water column in the well based on the previous two measurements (Note: If total depth is not measured prior to purging, use previous data and confirm after the groundwater sampling has occurred). Then calculate the volume of water in the well (well volume) and/or system using the following conversion factors:

Well or tubing Diameter (inches)	Gallons per Foot of Water
0.25	0.003
0.375	0.006
0.75	0.023
1.00	0.041
2.00	0.16
4.00	0.65
6.00	1.47
8.00	2.61
12.00	5.87

Well volume is important since the minimum required purge volume is usually based on a multiple of well or system volumes depending upon site-specific data needs.

- Attach and secure the appropriate tubing and line to the low-flow pump. Lower the pump and/or tubing slowly into the well and set the pump inlet at approximately the middle of the saturated screen and at least two feet above the bottom of the well to avoid mobilization of any sediment present at the bottom of the well. Document the location of the pump intake on the field logbook and/or sampling forms (Attachment A).
- Before starting the pump, measure the water level once again to document static water level after displacement from the pump installation. Document the water level in field logbook and/or sampling forms (Attachment A) prior to and after pump installation.
- Insert the measurement probes into the flow-through cell. Measurements should be obtained using a flow-through-cell except for turbidity, which should be measured separately with the use of a T-valve. This connection is to collect water before entering the flow-through-cell. The purged groundwater is directed through the cell, allowing measurements to be collected before the water contacts the atmosphere. The flow-through-cell should be kept at a 45 degree angle to minimize the entrapment of air bubbles.
- Start pump at its lowest speed setting and slowly increase the speed until discharge occurs. Initiate purging at a low rate (typically 0.2 to 0.5 liters per minute); avoid surging. Purging rates for more transmissive formations can be started at 0.5 liter to 1 liter per minute. Flow rate is measured with a graduated cylinder and a timepiece.
- The initial field parameters of pH, specific conductance, DO, ORP, turbidity, and temperature are measured and recorded in the field logbook and/or sampling forms (Attachment A).
- The water level should be monitored during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.3-feet). The water level should stabilize for the specific purge rate. There should be sufficient water over the pump intake so there is no risk of the pump suction being broken or entrainment of air in the sample.
- Record adjustments in the purge rate and changes in depth to water in field logbook and/or sampling forms (Attachment A). Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1- to 0.2-liter per minute) to avoid affecting well

drawdown. If the minimal draw-down that can be achieved is greater than 0.3 feet, continue purging until water levels, flow rate, and field indicator parameters stabilize.

- Wells with extremely low recharge rates may require the use of a bladder pump capable of attaining a very low pumping rate. If the recharge rate of the well is lower than the pump's minimum extraction rate, then continue to purge until the well is dry. The sample should be taken no sooner than two hours after purging and after a sufficient volume for a water-quality sample, or sufficient recovery (commonly 90%) is present (the intake should not be moved during this recovery period, if possible). In this case only, samples may be collected even if the well was not purged before field indicator parameters stabilized or the minimum purge volume was removed, however, this must be documented in the field logbook and/or sampling forms (Attachment A). Note: The pumping rate should not be lower than 40 milliliters per pulse if VOC samples are to be collected; this way VOA vials can be filled from a single pulse of water.
- During purging, the field parameters (pH, specific conductance, DO, turbidity, ORP and temperature) are measured approximately every five minutes (or as appropriate) until the parameters have stabilized. Purging is considered complete and sampling may begin when all the above field indicator parameters have stabilized and the minimum purge volume has been achieved. The minimum purge volume may be project or well-specific. For most wells, one to three well volumes should be purged prior to sampling depending upon well-volume, stabilization of field indicator parameters, and well-yield. Note: According to EPA Region 1, the absolute minimum purge volume that needs to be removed prior to sampling is the volume of drawdown plus the system volume (tubing). Stabilization is considered to be achieved when three consecutive readings, taken at approximately five minute intervals, are within the following ranges:
    - Turbidity – 10% (if values are greater than 5 NTU. If 3 values are < 5 NTUs, consider the values as stabilized)
    - DO – 10% (if values are greater than 0.5 mg/L. If 3 values are < 0.5 mg/L, consider the values as stabilized)
    - Specific conductance – 3%
    - Temperature – 3%
    - pH - +/- 0.1 units
    - ORP - +/- 10 millivolts

Once purging has been completed, the flow-through cell and T-valve are removed, and samples are collected directly from the discharge hose. The elapsed time between completion of purging and collection of the groundwater sample should be minimized. The pump should not be interrupted (i.e., pumping should not be stopped) prior to sampling. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. VOC samples are normally collected first and groundwater pumped directly into pre-preserved sample containers.

During purging and sampling, the pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that small diameter tubing (e.g., 1/4 inch) be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to

the sampling point (i.e., the well is evacuated to near dryness), pumping will stop until sufficient water collects in the well, the pump will be started, and samples collected.

5.0 GROUNDWATER SAMPLING USING PDB SAMPLERS

Passive Diffusion Bag (PDB) samplers are a cost-effective sampling alternative to standard or low-flow purge and sample techniques for collecting concentrations of a variety of VOCs in groundwater at monitoring wells. PDB sampling can also provide vertical contaminant concentration profiles that can be used to optimize remedial systems.

The PDB sampling procedure is used to collect groundwater samples from specific monitoring wells as identified by the project planning documents. The depth at which the PDB sampler is placed within the screened interval should be adjacent to the primary water-bearing zone, as identified through drilling/logging information. Multiple PDB samplers may be used in wells with screen intervals greater than 15 feet. The PDB sampler depth with the most elevated concentrations would be used to determine the optimal depth to place a single PDB sampler during subsequent sampling events.

A typical, standard-size PDB sampler is manufactured of low-density polyethylene (LDPE) lay-flat tubing sealed at both ends and contains approximately 220 milliliters (mL) of certified, laboratory-grade, analyte-free, deionized water. The assembled cylindrical bag is 12 to 24 inches long and 1.25 inches in diameter. A protective polyethylene mesh encompasses the PDB sampler to prevent contact between the LDPE tubing and the well casing. Two attachment holes, placed approximately 22 inches apart, are present in the tubing on both sides of the water-filled section. These holes are used to attach the suspension mechanism, which is typically a weighted line that is used to ensure that the PDB sampler is positioned at the desired sampling depth. The LDPE acts as a semi-permeable membrane that is permeable to certain contaminants. VOCs dissolved in groundwater diffuse across the membrane into the deionized water in the PDB sampler until equilibrium is established between the VOCs dissolved in the groundwater and in the deionized water. The mechanism used to suspend the PDB sampler at the desired depth within the screened interval consists of stainless-steel weights attached to the bottom of a line. The line may be made of polypropylene, polyester, nylon, stainless steel, or various polytetrafluoroethylene (PTFE) coated materials (depending on the contaminant of interest) that is of sufficient strength to support the PDB sampler(s) and the stainless-steel weights. The weights can be reused after each use providing they have been thoroughly decontaminated. Dedicated PTFE-coated or stainless-steel line can be decontaminated and reused, but polypropylene, polyester or nylon line will be dedicated or discarded after each use.

5.1 PDB Sampler Deployment

The following steps will be taken to deploy the PDB samplers:

- The groundwater depth will be accurately determined using a water level probe or similar instrument. This will be done to confirm the groundwater level is above the recommended PDB sampler installation depth.
- Measure and cut the suspension line according to the length needed. Knot the end of the line that is to be attached to the well cap so that it can easily be attached to the hook on the inside of the well cap once the PDB sampler has been deployed in the well.

- Attach the stainless steel weights to the end of the line used to suspend the PDB sampler in the well.
- Attach the PDB sampler(s) to the line; cable ties can be used to attach the PDB sampler to the line using the holes outside the sealed portion of the PDB sampler.
- Lower the PDB sampler(s) down the well and secure the line to a hook on the inside of the well cap.
- Reattach the well cap and secure the well.

5.2 PDB Sampler Recovery

A minimum 14-day equilibrium time is required for the PDB samplers.

- The weighted suspension line being used to suspend the PDB sampler(s) in the well from the well casing will be detached, and then attached to an anchored object so that the detached PDB sampler configuration is not inadvertently dropped into the open well.
- The PDB sampler(s) will be removed from the well using the attached weighted line, being careful to minimize agitation of the PDB sampler(s) and contact with the well casing.
- The outer surface of the PDB sampler will be examined for evidence of tears in the LDPE membrane or any coatings (i.e., iron or algae). Note any such observations in the field logbook and/or sampling forms. Any tears in the LDPE membrane will result in rejection of the sample.
- Detach and remove the PDB sampler(s) from the weighted line, set the weighted line aside for later decontamination, and remove any coatings or excess liquid from the exterior of the bag (this will minimize the potential for cross contamination).
- If more than one PDB sampler is being deployed in the well, the PDB samplers should be removed according to their vertical placement within the screened interval of the well, with the shallowest PDB sampler being removed first.

5.3 PDB Sample Collection

Groundwater samples will be collected from the PDB samplers immediately following removal from the well to minimize external effects acting on the bag. The following steps must be followed:

- Puncture the PDB sampler with a disposable straw (included with PDB samplers). Alternatively, remove fill plug and pour.
- Transfer the contents of the PDB sampler into the appropriate laboratory prepared sample containers sample containers by tilting the PDB sampler so that the groundwater contained in the bag pours out of the disposable straw or the incision made at the top of the unit. Care will be taken to minimize agitation during this step.
- Preserve the samples according to the analytical method and store the samples at 4°C (+/- 2°C) prior to shipping in accordance with standard sampling protocol.

- Dispose of the remaining contents of the PDB sampler according the project planning documents. Dispose of the used PDB sampler as investigation derived waste (IDW).

6.0 GROUNDWATER SAMPLING USING RCDM SAMPLERS

Regenerated Cellulose Dialysis Membrane (RCDM) samplers are a cost-effective sampling alternative to standard or low-flow purge and sample techniques for collecting concentrations of a variety of VOCs and inorganic constituents in groundwater at monitoring wells. RCDM sampling can also provide vertical contaminant concentration profiles that can be used to optimize remedial systems.

This type of diffusion membrane sampler is constructed from commercially available tubular RCDM. The dialysis membrane allows the passage of both dissolved inorganic and organic contaminants from groundwater into the sampler. The RCDM tubing can be purchased in a variety of diameters so the sampler may be configured to fit in both small- and large-diameter wells. The RCDM samplers can be made in various lengths to allow for the collection of a sufficient volume of water necessary for the target analyses. Samplers made with RCDM must be kept hydrated between the time they are constructed and deployed. This is easily remedied by storing the RCDM sampler in a polyethylene sleeve partially filled with water.

The RCDM samplers are relatively low in cost, only slightly more than PDB samplers, and are disposable after one use. RCDM samplers have been shown to effectively sample wells for major cations, anions, nutrients, most trace metals, all VOCs, dissolved organic carbon, and methane (Imbrigiotta et al., 2007). Demonstration of the utility of RCDM samplers for other constituents (e.g., perchlorate and explosives) has also been documented (Imbrigiotta et al., 2008).

6.1 RCDM Sampler Deployment

RCDM samplers are deployed in the open interval of wells at the depths of highest mass flux of the primary chemicals of concern at each site. Depths are chosen based on knowledge of the well construction and/or water-chemistry results from previous sampling at each well. The RCDM sampler is suspended by the mesh liner with the valve facing downward to maximize recovery.

- The groundwater depth will be accurately determined using a water level probe or similar instrument. This will be done to confirm the groundwater level is above the recommended RCDM sampler installation depth.
- Measure and cut the suspension line according to the length needed. Knot the end of the line that is to be attached to the well cap so that it can easily be attached to the hook on the inside of the well cap once the RCDM sampler has been deployed in the well.
- Attach the stainless steel weights to the end of the line used to suspend the RCDM sampler in the well.
- Attach the RCDM sampler(s) to the line; cable ties can be used to attach the sampler to the line. The RCDM sampler is suspended by the mesh liner with the valve facing downward to maximize recovery.
- Lower the RCDM sampler(s) down the well and secure the line to a hook on the inside of the well cap.

- Reattach the well cap and secure the well.

6.2 RCDM Sampler Recovery

The RCDM samplers are allowed equilibrate for one to two weeks prior to sample retrieval, depending upon the target constituents selected.

- The weighted suspension line being used to suspend the RCDM sampler(s) in the well from the well casing will be detached, and then attached to an anchored object so that the detached sampler configuration is not inadvertently dropped into the open well.
- The RCDM sampler(s) will be removed from the well using the attached weighted line, being careful to minimize agitation of the sampler(s) and contact with the well casing.
- The outer surface of the RCDM sampler will be examined for evidence of tears in the membrane or any coatings (i.e., iron or algae). Note any such observations in the field logbook and/or sampling forms. Any tears in the membrane will result in rejection of the sample.
- Detach and remove the RCDM sampler(s) from the weighted line, set the weighted line aside for later decontamination, and remove any coatings or excess liquid from the exterior of the sampler (this will minimize the potential for cross contamination).
- If more than one RCDM sampler is being deployed in the well, the samplers should be removed according to their vertical placement within the screened interval of the well, with the shallowest sampler being removed first.

6.3 RCDM Sample Collection

Groundwater samples will be collected from the RCDM samplers immediately following removal from the well to minimize external effects acting on the sampler. The following steps must be followed:

- Samples from the RCDM sampler are collected directly from the valve at the bottom of the sampler.
- Transfer the contents of the RCDM sampler into the appropriate laboratory prepared sample containers. Care will be taken to minimize agitation during this step.
- Preserve the samples according to the analytical method and store the samples at 4°C (+/- 2°C) prior to shipping in accordance with standard sampling protocol.
- Dispose of the remaining contents of the RCDM sampler in accordance with project planning documents. Dispose of the used sampler as investigation derived waste (IDW).

7.0 GROUNDWATER SAMPLING PROCEDURES FOR EXTRACTION WELLS

Extraction wells that are in operation will be sampled directly from the sampling port installed on the discharge line from each well (direct fill). Because extraction wells typically will be in continuous operation, purging and field parameter stabilization will not be used as criteria for sampling. For those wells not in operation at the time of sampling, the sampling techniques described above for the standard sampling technique will be used to collect a groundwater sample.

8.0 REFERENCES

Imbrigiotta, T.E., Trotsky, J. S., Place, M.C., 2007. *Demonstration and validation of a regenerated cellulose dialysis membrane diffusion sampler for monitoring ground-water quality and remediation progress at DoD sites (ER-0313).* ESTCP Final Technical Report for Project ER-0313.

Imbrigiotta, T.E., Trotsky, J. S., Place, M.C., 2008. *Protocol for use of regenerated cellulose dialysis membrane diffusion samplers (ER-0313).* ESTCP Protocol Report for Project ER-0313.

Vroblesky, D., 2001. *User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells*. USGS Water-Resources Investigations Report 01-4060.

US Environmental Protection Agency, 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*, Ground Water Forum Issue Paper. EPA 542-S-02-001. May.

US Environmental Protection Agency Region 1, 2017 *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.* Revision 4. September.

Attachment A

Groundwater Sampling Log

KOMAN GOVERNMENT SOLUTIONS LLC

Low Flow/ Low Stress Groundwater Sampling Log

Well Identification: _____

Project: _____ Date: _____

Location: Fort Devens Massachusetts Sampler: _____

Well Integrity

	Yes	No	N/A
Casing Secure			
Concrete Pad intact			
PVC casing intact			
Well gripper present			
Bolts present			
Locked (stickup wells)			

Well Information

Diameter	
Material	
Depth to water (ft-bgs)	
Depth to bottom (ft bgs)	
Screen Interval (ft-bgs)	
Total volume purged (gal)	

Sampling Type

Purging Method _____ Tubing type _____ Dedicated pump (Y/N) _____

Purge start/stop time _____ Tubing diameter _____ Air source _____

Field Instrument (Model/S/N) _____

Stabilization Parameters

Time (hhmm)	Flow Rate (ml/min)	Depth to Water (ft)	Temp (°C)	pH (STD)	SPC (µS/cm^c)	DO (mg/L)	ORP (mv)	Turbidity (NTU)	Color/Clarity
Acceptance Criteria:		<0.3ft	±3%	±0.1	±3%	±10%	± 10mv	10%	

2" Screen Volume = 0.163 gal/ft or 616 ml per foot Per EPA Region 1 Low Flow SOP V3, 1/19/10

Sampling Details

Field Filtered (Y/N): _____ Duplicate (Y/N): _____ MS/MSD (Y/N): _____

Filter Size: _____ Dup ID/Time: _____

Sample Collection Time: _____

Comments: _____

_____

_____ _____

Signature Date

KOMAN Government Solutions, LLC	STANDARD OPERATING PROCEDURE	Number SOP-F004	Page 1 of 13
		Effective Date 8/15/2017	Revision 0
		Applicability KOMAN Government Solutions	
		Prepared by: Ericka Seiler	
Subject: **SEDIMENT AND SURFACE WATER SAMPLING**		Approved by: Stephen Deeter	

TABLE OF CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the methods, the sequence of operations, and the equipment necessary to collect surface water and sediment samples for laboratory analyses. The goal of this SOP is to provide consistent and repeatable methodology for the collection of representative samples from surface water and sediment to be evaluated for the presence of contamination or other project specific requirements.

2.0 SCOPE AND APPLICABILITY

The procedures described herein are applicable to all sediment and surface water sampling situations. Sediment and surface water samples will be analyzed for chemical and/or physical parameters that are specific to the technical project objectives as identified in the project planning documents.

3.0 SEDIMENT SAMPLING PROCEDURES

When collecting sediment samples, several general precautions should be noted, as follows:

- Assess the entire project area and, unless the sample locations are predefined in the project planning document, the sampling team should use their judgment on selecting the most representative location.
- In cases where sediment samples are to be collected at the same time and location as surface water samples, the sediment samples should be collected after the co-located surface water samples to avoid disturbing the sediment and possibly biasing the surrounding surface water with suspended sediment.
- When using watercraft, take samples near the bow, away and upwind from any gasoline outboard engine. Orient watercraft so that bow is positioned in the upstream direction.
- When wading, collect samples upstream from the body.
- Unless dictated project planning documents, sampling at or near structures (e.g., dams, weirs or bridges) may not provide representative data because of unnatural flow patterns.
- Collect samples from downstream towards upstream.

All observations shall be recorded in the field notebook or on the Surface Water and Sediment Sampling Log (Attachment A).

3.1 EQUIPMENT

All sampling equipment that may come in contact with samples or sampling surfaces should be constructed of materials that are compatible with the selected target analyses. The following equipment/materials may be required for the performance and documentation of the sediment sampling effort:

- Site map, sample location coordinates, field logbook, and sampling log;
- Surveyor tape, stakes, buoys, or flagging;
- Laboratory-prepared sample bottles with labels;
- Shipment coolers with ice;

- Clean, laboratory-supplied, unpreserved, plastic bottles with the tops cut off for use as disposable/dedicated sediment sample collection devices;
- Stainless steel, polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE, i.e., Teflon™), or other analysis-specific inert materials to be used for all sample collection;
- Hand tools and screws or other fasteners for assembling sample retrieval devices;
- Crow bars, lifting hooks, and/or other appropriate tools if necessary, for lifting manhole covers, vault covers, storm water outfall lids, etc.

3.2 SEDIMENT SAMPLING

Sediment samples typically are collected using one of three types of equipment: scoops, corers, and dredges or grab samplers. Soil sampling equipment is generally not applicable to sediments because of the low cohesion of the medium.

When selecting the appropriate sampling equipment, consider sampling location (edge or middle of lagoon), depth of water and sediment, sediment grain size (fineness), water velocity, and target analyses. Direct collection with the appropriate sample container may be appropriate in very low water or where sediment is exposed. Dredges are appropriate for hard or rocky substrates and are heavy enough to use in high velocity streams. Coring devices can be used in quiescent waters, unless water depth precludes effective sample collection.

3.2.1 Scoops

Scoops or similar equipment are generally most useful around the margin or shore of the water body or when wading in shallow waters.

- Collect sediment samples beginning with the most downstream sampling location.
- Stand facing the direction of flow and approach the location from the downstream direction.
- Take precautions not to disturb the bottom prior to scooping.
- Scoop the sample in the upstream direction of flow.
- For obtaining samples several feet from shore or from a boat, attach the scoop to an extendible pole.

3.2.2 Coring Devices

Coring devices are available commercially and can be fabricated from various materials. Some corers are simple "push tubes," whereas other more sophisticated models may be finned, gravity driven devices. Although stainless steel, glass, or PTFE must be used for sampling volatile and semi-volatile organics and inorganics, aggregate organics, petroleum hydrocarbons, and oil and grease; other inexpensive material (e.g., PVC, carbon steel, etc.) may be used for inorganic non-metallic constituents or other sensitive compounds [e.g., Per- and Polyfluoroalkyl Substances (PFAS)].

A core may be useful for preserving the historical layering of sediments. Water displacement is minimal with core samplers, which minimize the shock wave produced by other equipment such as dredges as they descend through the water column. The corer is an acceptable choice for

sampling fine sediments in static waters, especially those containing trace organics and metals.

Core diameter, grain size, and sample consistency will determine if the sample will remain in the corer upon withdrawal. Sample washout can be a problem and there are several ways to reduce or prevent it.

- Fit the leading edge of the corer with a nosepiece or core catcher that physically keeps the sample from slipping back out of the corer. The core catcher material must also be compatible with the analyses of interest, or
- Fit the top or back end with a check valve which creates negative pressure on the back of the sample as it is being pulled from the substrate and prevents surface water from washing out the top portion of the sample.

When using a coring device:

- Rotate the corer, if needed, as it is pushed into the sediment.
- Rotate around its axis (do not rock the coring device back and forth).
- Rotation improves penetration and prevents compaction of the sample as it is pushed to the full length of the corer.
- Upon withdrawal from the water surface, place a cap on the bottom to prevent the sample from sliding out.

Corers can also be fitted with liners. This is advantageous if a complete core is desired that has not been in contact with the atmosphere. It is also advantageous if the coring device is not constructed of the proper material (e.g., PVC) and one of the target analyses requires a sampler of inert construction (e.g., glass, stainless steel, or PTFE).

As the core is extruded, carefully remove the sample with a clean, non-reactive utensil and transfer into the appropriate sample container(s).

3.2.3 Dredges or Grab Samplers

Three main types of devices are used in freshwater systems: Ekman, Peterson, and Ponar dredges. Heavier oceanographic dredges are used in marine and estuarine waters. The Peterson and Ponar dredges are suitable for hard or rocky substrates or deep-water bodies.

The Peterson and Ponar dredges are virtually the same, except that the Ponar has been adapted with a top screen and side plates to prevent sample loss upon ascent. For this reason, the Ponar is the dredge of choice for rocky substrates. These dredges are heavy enough for use in streams with fast currents.

- Open the jaws and place the cross bar into the proper notch.
- Lower the dredge to the bottom, making sure it settles flat.
- When tension is removed from the line, the cross bar will drop, enabling the dredge to close as the line is pulled upward during retrieval.
- Pull the sampler to the surface. Check to make sure the jaws are fully closed and that no sample was lost while lifting the dredge.

- Carefully open the jaws, remove the sample with a clean, non-reactive utensil and transfer the sample into the appropriate sample container(s).

The Ekman dredge is designed for sampling soft substrates (e.g., sand, silt, and/or mud) in areas with little current.

- Open the spring-loaded jaws and attach the chains to the pegs at the top of the sampler.
- Lower the dredge to the bottom, making sure it settles flat.
- Holding the line taut, send down the messenger to close the jaws of the dredge.
- Pull the sampler to the surface. Check to make sure the jaws are fully closed and that no sample was lost while lifting the dredge.
- Carefully open the jaws, remove the sample with a clean, non-reactive utensil and transfer the sample into the appropriate sample container(s).

3.3 SAMPLING HANDLING

Preserve the samples according to the analytical method, store the samples at 4 degrees Celsius (°C) (+/- 2°C) prior to shipping in accordance with standard sampling protocol.

4.0 SURFACE WATER SAMPLING PROCEDURES

When collecting surface water samples, several general precautions should be noted, as follows:

- Assess the entire project area and, unless the sample locations are predefined in the project planning document, the sampling team should use their judgment on selecting the most representative location.
- When using watercraft, take samples near the bow, away and upwind from any gasoline outboard engine. Orient watercraft so that bow is positioned in the upstream direction.
- When wading, collect samples upstream from the body.
- Avoid disturbing sediments in immediate area of sample collection.
- Collect water samples prior to taking sediment samples when obtaining both from the same area (site).
- Consider the representativeness of selected sampling locations, for example, when attempting to characterize a water body that may be stratified or heterogeneous.
- Unless dictated project planning documents, sampling at or near structures (e.g., dams, weirs or bridges) may not provide representative data because of unnatural flow patterns.
- Collect surface water samples from downstream towards upstream.

All observations shall be recorded in the field notebook or on the Surface Water Sampling Log (Attachment A).

4.1 EQUIPMENT

The following equipment/materials may be required for the performance and documentation of the surface water sampling effort:

- Site map, sample location coordinates, field logbook, and sampling log;
- Surveyor tape, stakes, buoys, or flagging;
- Laboratory-prepared sample bottles with labels;
- Shipment coolers with ice;
- Clean, laboratory-supplied, unpreserved, plastic bottles with the tops cut off for use as disposable/dedicated surface water sample collection devices;
- Stainless steel, polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE, i.e., Teflon™), or other analysis-specific inert materials to be used for all sample collection. Examples of equipment that may be used for depth grab sampling include Kemmerer, Niskin, Van Dorn, and similar samplers, pumps with tubing, and double check-valve bailers;
- Hand tools and screws or other fasteners for assembling sample retrieval devices.

4.2 MANUAL SURFACE WATER SAMPLING

Manual sampling is typically used for collecting grab samples for immediate in-situ field analyses. Manual sampling is also used in lieu of automatic equipment over extended periods of time for composite sampling, especially when it is necessary to observe and/or note unusual conditions.

Surface Grab Sampling

Collect surface grab samples within the top 12 inches of the water column. Avoid skimming the surface of the water during collection unless specifically required by the approved project planning documents. Very shallow water bodies require careful techniques of sample collection to avoid disturbing sediments:

- Do not collect a grab sample from water less than ten centimeters (cm) deep because of the risk of disturbing sediment or flocculent bottom material.
- Especially for waters with low or no flow, use extreme caution to avoid disturbing the sediment.
- Use of an intermediate device may be appropriate to avoid creation of a sediment plume in cases of low or no flow.

Where practical, use the actual sample container as the collection device (direct grab). Sample containers attached to poles are also considered direct grabs.

The use of unpreserved sample containers is encouraged as the same container can be submitted for laboratory analysis after appropriate preservation. This procedure reduces sample handling and potential loss of analytes or contamination of the sample from other sources (e.g., additional sampling equipment, environment, etc.).

For the Direct Grab Technique using an unpreserved sample container to collect the sample, use the following procedure:

- Remove the container cap and slowly submerge the container, opening first, into the water.

- Invert the bottle so the opening is upright and pointing upstream into the oncoming direction of water flow (if applicable). Allow water to run slowly into the container until filled.
- Return the filled container quickly to the surface.
- Pour out a small volume of sample away from and downstream of the sampling location. This procedure allows for addition of preservatives and sample expansion. Do not use this step for volatile organics or other analytes where headspace is not allowed in the sample container.
- Add preservatives, if required, securely cap container, label, and complete field notes.

For the Direct Grab Technique using a sample container with pre-measured preservative to collect the sample, (an unpreserved sample container may also be used with this technique) use the following procedure:

- Submerge the unopened sample container to the appropriate level.
- Turn the container so that the opening is upright and pointing upstream into the oncoming direction of water flow (if applicable).
- Open the container and allow the water to run into the container almost full (leave an air space).
- Cap the container and return to the surface.
- If preservatives have been added, invert the container several times to ensure sufficient mixing of sample and preservatives.
- Check preservation of the sample and adjust pH with additional preservative, if necessary. When a pH adjustment is made and a pre-preserved container was used to collect the sample, always check all containers for proper preservation.

Depth Grab Sampling

Kemmerer, Niskin, and Van Dorn type devices are typically constructed of plastic and rubber that preclude their use for all volatile and extractable organic sampling. Some newer devices are constructed of stainless steel or are all polytetrafluoroethylene (PTFE) (i.e., Teflon™) or PTFE-coated. These are acceptable for all analyte groups without restriction. The following procedure should be followed:

- Measure the water column to determine maximum depth and sampling depth prior to lowering the sampling device.
- Mark the line attached to the sampler with depth increments so that the sampling depth can be accurately recorded.
- Lower the sampler slowly to the appropriate sampling depth, taking care not to disturb the sediments.
- At the desired depth, send the messenger weight down to trip the closure mechanism.
- Retrieve the sampler slowly.

- Rinse the sampling device with ample amounts of site water prior to collecting the first sample. Discard rinsate away from and downstream of the sampling location.
- Fill the individual sample bottles via the discharge tube.

Double Check-Valve Bailers are typically used if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. Bailers with an upper and lower check-valve can be lowered through the water column and water will continually be displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. Although not designed specifically for this kind of sampling, a bailer is acceptable when a mid-depth sample is required. The following procedure should be used:

- As the bailer is dropped through the water column, water is displaced through the body of the bailer. The degree of displacement depends upon the check-valve ball movement to allow water to flow freely through the bailer body.
- Slowly lower the bailer to the appropriate depth. Upon retrieval, the two check-valves seat, preventing water from escaping or entering the bailer.
- Rinse the sampling device with ample amounts of site water prior to collecting the first sample.
- Fill the individual sample bottles via the discharge tube.

Pump and Tubing Sampling

Note that the collection of sample fractions for oil and grease, total petroleum hydrocarbons, semi-volatile, and volatile organic compounds in surface water by the pump and tubing method is typically not used because of the potential for the loss of target compounds. The approved project planning documents should be reviewed to determine specific requirements and restrictions. If applicable, the following procedure should be followed for this method:

- Measure the water column to determine the maximum depth and the sampling depth.
- Tubing should be tied to a stiff pole or be weighted down so the tubing placement will be secure. Do not use a lead or metallic weight if collecting metals samples. Any dense, non-contaminating, non-interfering material will work (brick, stainless steel weight, etc.). Tie the weight with a lanyard (braided or monofilament nylon, etc.) so that it is located below the inlet of the tubing.
- Pump several tubing volumes through the system to flush the tubing prior to collecting the first sample.
- Fill the individual sample bottles via the discharge tube, being careful not to remove the inlet tubing from the water. Do not touch the discharge tubing to the sample container.
- Leave adequate headspace in the sample container. This procedure allows for addition of preservatives (if required) and sample expansion. Do not use this step for volatile organics or other analytes where headspace is not allowed in the sample container.
- Add preservatives if required, securely cap container, label and complete field notes.
- Invert the container several times to ensure sufficient mixing of sample and preservatives.

- Check preservation of the sample and adjust pH with additional preservative, if necessary.

4.3 AUTOMATIC SAMPLING

Automatic samplers are used when sites are to be sampled at frequent intervals or when a continuous sample is required. Composite samplers can be used to collect time composite or flow proportional samples. As noted for the pump and tubing sampling method, the collection of sample fractions for oil and grease, total petroleum hydrocarbons, semi-volatile, and volatile organic compounds in surface water by automatic samplers is typically not appropriate because of the potential for the loss of target compounds. The approved project planning documents should be reviewed to determine specific requirements and restrictions.

The use of automatic samplers for collecting surface water samples will more frequently occur in situations where sampling equipment is deployed on-site for a long term or dedicated to the site. The following procedure should be used:

- Use all new or precleaned pump tubing each time the sampler is brought to the field and set up. If the automatic sampler is deployed in the field for extended periods, it is recommended to replace the tubing at a minimum of every six months. Other replacement schedules may be required, depending on the specific installation and project requirements.
- Inspect the tubing each time the composite-sample container is picked up. If there is evidence of loss of elasticity or discoloration or other conditions that would impact the quality of the sample (such as algal growth), or the pumping flow rate, then replace the tubing. Select the tubing for the pump head and sampling train according to the target parameters and the appropriate construction materials.
- Cut the proper length of precleaned tubing (e.g., PTFE, polyethylene, etc.).
- Collect equipment blanks each time the tubing is changed or at a frequency of 5% of the tubing changes, whichever is less. Collect a minimum of one blank each year. Collect the blank by passing analyte-free water through the equipment that is exposed to the sample.
- Composite sample containers may be cleaned either in the field or in a fixed base operation. Demonstrate cleaning effectiveness by collecting equipment blanks on the composite sample containers according to the frequency specified in the approved project planning documents
- Collect sample container equipment blanks by adding analyte-free water to the cleaned sample container, mix the water thoroughly within the container and then pour off an aliquot for analysis.
- Put the collection sieve and tubing in the appropriate sample location, using conduit if necessary to hold it in place. Ensure the supporting conduit does not contaminate the incoming sample water.
- Program the sampler per manufacturer’s directions and as required in the permit or project planning documents.

- Place a lock or seal on the sampler to prevent or detect tampering. Note that this procedure, however, does not prevent tampering with the sampler tubing.
- At the end of each sampling period, stir the contents of the composite jug and transfer the contents into the respective containers. If the sampler was configured to collect discrete samples ensure that the contents of each container are adequately mixed while pouring the sample into the sample container.
- Immediately preserve the sample, if required, securely cap container, label, and complete field notes.
- In certain sampling situations, automatic composite samplers are permanently installed at surface water stations and remain in the field for months or even years. Under these conditions, there are specific sampling issues that need to be addressed; the sampling team should review the project planning documents to verify project-specific requirements and restrictions.
- Clean composite sampler containers after collection of each composite sample using cleaning solutions and procedures specified in the approved project planning documents.
- Composite sample containers may be cleaned either in the field or in a fixed based operation. Demonstrate cleaning effectiveness by collecting equipment blanks on the composite sample containers according to the frequency the project planning documents.
- Collect sampler container equipment blanks by adding analyte-free water to the cleaned sample container, mix the water thoroughly within the container and then pour off an aliquot for analysis.
- Inspect and replace tubing at a minimum of every six months or when applicable.
- If the tubing is being replaced for multiple autosamplers at the same time, one equipment blank may be collected on the entire length of replacement tubing. Collect this equipment blank by passing analyte-free water through the entire length of new tubing.

4.4 SAMPLE HANDLING

Preserve the samples according to the analytical method, store the samples at 4 degrees Celsius (°C) (+/- 2°C) prior to shipping in accordance with standard sampling protocol.

5.0 REFERENCES

USEPA Region 9 Laboratory, 1999. *Field Sampling Guidance Document #1215, Sediment Sampling. Rev 1*. September 1999.

USEPA Region 4, 2013. *SESD Operating Procedure, Surface Water Sampling*. SESDPROC-201-R3. February 2013.

U.S. Geological Survey. Variously Dated. *National Field Manual for the Collection of Water-Quality Data*. U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapters. A1-A10. Online at http://pubs.water.usgs.gov/twri9A.

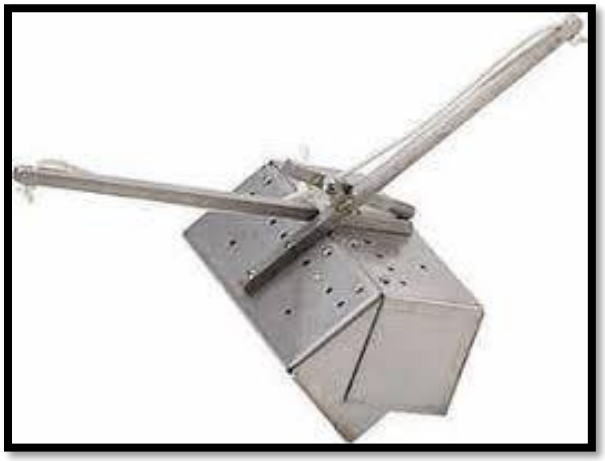
Typical PVC Dipper
(Global Nasco)

Sediment Corer
(AMS™ Sludge Sampler)

Weighted Corer
(Ben Meadows)

Ponar Dredge
(Cole Parmer)

Ekman Dredge
(Forestry Suppliers)



Attachment A

Surface Water and Sediment Sampling Log

KOMAN Government Solutions, LLC

Surface Water and Sediment Sampling Log

Project: _____ **Date/Time:** _____

Location: _____ **Sampler:** _____

Sample Location ID: _____

Surface Water/Leachate Seep Information

Type of SW: ( ) Stream ( ) River ( ) Seep

Water Depth:	Dissolved Oxygen (mg/L):
Velocity of Water:	ORP (mV):
Temperature (C):	Specific Conductance (µS/cm):
pH (STD):	Turbidity (NTU):

Sample Observations:

( ) Odor

( ) Color

( ) Other

Field Testing Equipment:

Make Model Serial #

Sediment/Leachate Seep Sediment Information

Sediment Type: ( ) Organic ( ) Gravel ( ) Clay ( ) Silt ( ) Sand ( ) Other _____

Type of Sample Collected: ( ) Discrete ( ) Composite

Sample Observations:

( ) Odor

( ) Color

( ) Other

Samples Collected

Sample ID	Sample Location	Time	Matrix	# of Bottles	Preservative	Analysis

Comments:

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		Effective Date 8/15/2017	Revision 0
		Applicability KOMAN Government Solutions	
		Prepared by: Ericka Seiler	
Subject: **DECONTAMINATION OF FIELD EQUIPMENT**		Approved by: Stephen Deeter	

TABLE OF CONTENTS

1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving and/or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment, chemical sampling equipment, and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible; single-use, sealed, disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

3.0 PROJECT PLANNING

Decontamination methods and equipment requirements may differ from project to project. General equipment items are specified in this section but specific equipment must be obtained to address the project-specific contamination procedures presented the approved project planning documents. Typical equipment and materials required to support decontamination efforts are provided in the following list:

- Decontamination pad materials for larger equipment (i.e., wood for the frame, tools for constructing frame, polyethylene sheeting or comparable material to cover decontamination pad frame, wash/drying racks for auger flights and drill/drive rods), when applicable.
- Personal Protective Equipment (PPE), as specified in the project health and safety plan.
- Detergent (e.g., Alconox) and potable water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol, hexane, etc.) for rinsing.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Tubs, buckets, drums, etc. for containerizing rinse water.
- Paper towels or cloths for wiping and/or drying.

Additional equipment and materials that may be needed include:

- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment or organic vapors generated through the existence of residual contamination or the presence of decontamination solvents remaining after rinsing.

- Aluminum foil or clear plastic bag for covering cleaned equipment.
- Sample bottles for collecting rinsate blanks.
- Paper towels or cloths for wiping.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items.
- Drum-moving equipment for moving filled waste drums.
- Drum labels for waste drums (see Attachment A).

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, prior planning is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary/Centralized/Permanent decontamination pads/facilities
- Sample locations
- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as identified in the project-specific planning documents and/or may be as dictated by site conditions as long as the overall requirements of the project planning documents are met. It should be noted that sampling for certain chemical groups may require specific decontamination materials, such as solvent rinses, to ensure appropriate cleanliness of reusable sampling equipment. The field team should carefully review all project-specific planning documents to evaluate the need for special decontamination procedures.

4.0 DECONTAMINATION PROCEDURES

4.1 TEMPORARY DECONTAMINATION PADS

Temporary decontamination pads may be constructed at satellite locations within the project site in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

The decontamination site selected should be far enough from the work site to minimize potential cross-contamination while minimizing travel distance. The location of the decontamination site

shall be selected to provide, in the judgment of the Field Operations Leader (FOL) or FOL designee, compliance with as many of the following characteristics as practicable:

- Well removed from pedestrian/vehicle thoroughfares.
- Avoidance of areas where control/custody cannot be maintained.
- Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.
- Avoidance of other potentially contaminated areas.
- Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

The selected decontamination site should include the following, where possible:

- Areas where potable water and electricity are provided.
- Areas where support activities such as removing decontamination water, soil, and sediment are possible without entering an active exclusion zone.
- Areas that offer sufficient size to carry out the specific decontamination sequence.

The decontamination pad should be constructed to meet the following characteristics:

- Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses, and minimizing splash due to work in close quarters.
- Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks.
- Sidewalls – The sidewalls should be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with polyethylene sheeting covers to control overspray.
- Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp objects (e.g., sticks, stones, debris, etc.) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of six (6) thousandths of an inch (also known as a "*mil*") to 30 mil. The desired thickness

may be achieved through layering materials of lighter construction. It should be noted that various materials (e.g., rubber, polyethylene, etc.) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.

- Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off from the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

4.2 DECONTAMINATION ACTIVITIES AT DRILL RIGS/DPT UNITS

During subsurface sampling activities, including drilling and DPT activities, decontamination of drive rods, core samplers, split barrel samplers (i.e., split spoons), etc. may be conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as appropriate for temporary pads to permit parts to dry and be evaluated prior to use/reuse.

4.2.1 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure will be employed prior to initiating the drilling/sampling activity, then between locations:

1. Remove loose soil using shovels, scrapers, etc.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.
3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporated rinsing as part of the process).
4. If the equipment has directly or indirectly contacted contaminated media and is known or suspected of being contaminated with hard to remove organic materials, rinse equipment with pesticide-grade isopropanol and/or hexane, as appropriate.
5. To the extent possible, allow components to air dry.
6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a PID/FID to ensure that all contaminants and possible decontamination solvents (if used) have been adequately removed.
7. Wrap or cover equipment in clear plastic until it is time to be used.

In general, follow the rules below to avoid injury, equipment damage, or incomplete

decontamination:

1. Read the operating manual and follow the manufactures' recommended safety practices before operating pressure washers and steam cleaners.
2. Never point a pressure washer or steam cleaner at another person or use it to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.
3. Always wear PPE (e.g., hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection) as specified in the project health and safety plan. PPE will be identified in your project specific planning documents.
4. Inspect all equipment before use. An inspection checklist will be provided in the project-specific planning documents. If the equipment is rented, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of any equipment, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.

Do not modify equipment unless in accordance with manufacturer approved modifications.

4.3 FIELD EQUIPMENT DECONTAMINATION PROCEDURES

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and sampling (i.e., nitrile) gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

4.3.1 Groundwater Sampling Equipment

This includes pumps inserted into monitoring wells such as bladder pumps, Whale™ pumps, and Redi-Flo™ pumps, and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.
2. Scrub using soap and water and/or steam/pressure clean the outside of the pump/bailer and, if applicable, the pump tubing. Ensure that high temperatures from the steam/pressure washer won't affect soft parts of the pumps (i.e., bladders, seals, wiring, etc.).
3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run sufficient amount of soapy water through the pump/bailer to flush out any residual well water.
4. Remove the pump and tubing/bailer from the container.
5. Rinse external pump components using tap water.

6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).
7. If groundwater contains or is suspected to contain oil, grease, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol or hexane. Ensure that solvents won't affect soft parts of the pumps (i.e., bladders, seals, wiring, etc.).
8. Pass deionized water through the pump/bailer to flush out the tap water and solvent residue as applicable.
9. Drain residual deionized water to the extent possible.
10. Allow components of the equipment to air dry.
11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol/hexane (as appropriate), and deionized water, and allow to dry.
12. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed.
13. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples.
14. Wrap pump/bailer in aluminum foil or a clear plastic bag for storage.

4.3.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, additional periodic decontamination should be conducted as follows:

1. Wash with soap and water.
2. Rinse with tap water.
3. Rinse with deionized water.

4.4 MISCELLANEOUS EQUIPMENT

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples

in the cooler(s) provided is too great and request a replacement unit.

- Cleanliness – As per industry standard, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:
  1. Wash with soap and water.
  2. Rinse with tap water.
  3. Dry.

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

4.5 SOIL/SEDIMENT SAMPLING EQUIPMENT

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, hand-held core samplers, etc.

1. Remove all loose soil from the equipment through manual means (e.g., brushing, scraping, wiping, etc.).
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.
3. Rise the equipment with tap water.
4. If the equipment is contaminated or suspected to be contaminated with hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol or hexane, as appropropriate.
5. Rinse the equipment with deionized water.
6. To the extent possible, allow components to air dry.
7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.
8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device.
- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.
- Extract the dredge and wash it in soap and water per the project-specific planning documents.

4.6 CONTACT WASTE/MATERIALS

During the course of field investigations, disposable/single-use equipment becomes

contaminated. These items include tubing, trowels, PPE (gloves, over boots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule includes extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable Federal, State, and local regulations.

4.7 INVESTIGATION-DERIVED WASTES – DECONTAMINATION WASH WATERS AND SOLIDS

Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred to thousands of gallons in cases where large equipment required cleaning and the duration of the project activities. IDW containers can range from 55-gallon drums to large frack tanks and roll-off containers. The following procedures should be implemented to manage site IDW:

1. Label waste storage containers appropriately labeled (see Attachment A).
2. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:
    - Enclose areas accessible by the general public using construction fencing and signs.
    - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
    - Maintain the retaining bolt and label on the outside of storage containers where readily visible.
    - Provide at least four feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.
    - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the project manager at the termination of each shift.
    - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.
    - Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

4.8 DECONTAMINATION AREA MAINTENANCE

The primary objective of the decontamination process is to ensure that all equipment used to sample environmental media, or to provide access to environmental sampling locations, is maintained in a clean condition prior to and following use. In addition, the decontamination process ensures that site contaminants are not transported outside of the area of investigation, and that site workers are not exposed to contaminants on-site or by inadvertent contact exposure to contaminated equipment outside of the site. In order to facilitate achievement of these goals, the designated decontamination area must also be maintained in a clean condition to the extent

practicable by periodic maintenance, as described in the following:

1. Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards.
2. Regularly cleaning of the decontamination pad to prevent cross-contamination. This includes periodically draining the pad of water into IDW drums, scraping of gross soil and sediment from the pad into IDW drums.
3. PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

4.9 DECONTAMINATION EVALUATION

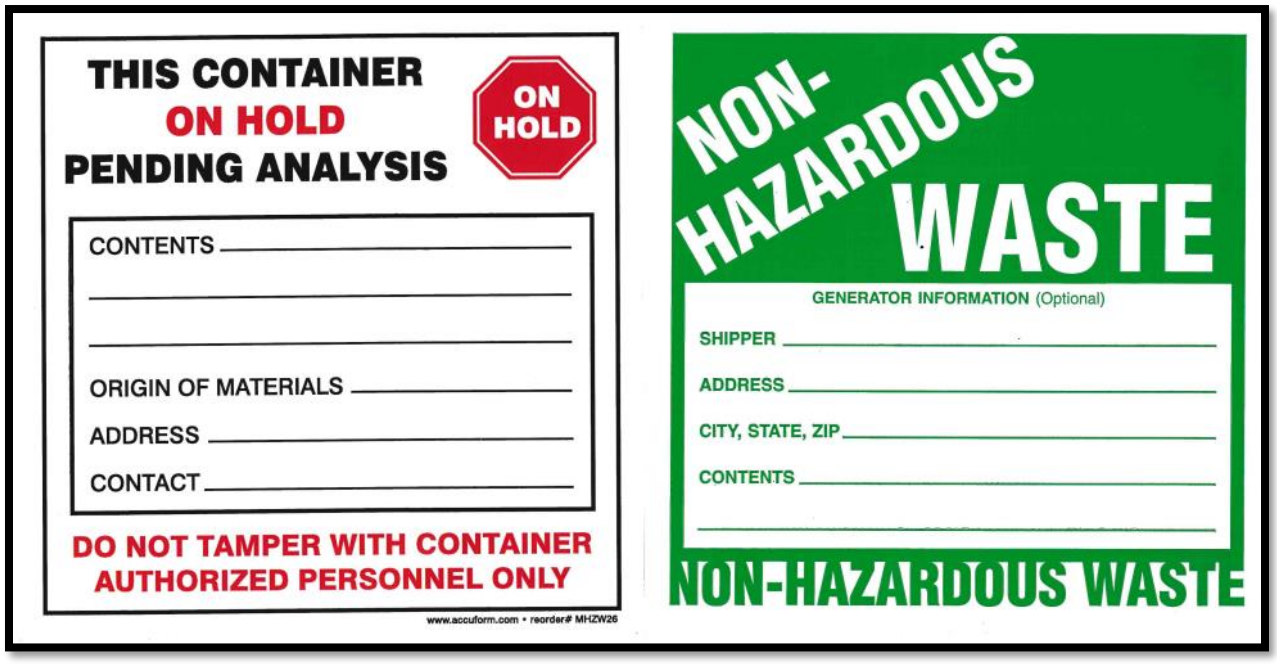
To further ensure that the decontamination objectives noted in Section 4.5 are achieved, upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of gross particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.
- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.
- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:
  - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.
  - The collection and the frequency of collection of rinsate samples will be specified in the project-specific planning documents, but are typically 1 sample in 20 field samples.

5.0 REFERENCES

USEPA, Region 4, 2015. Field Equipment Cleaning and Decontamination, SESDPROC-205-R3. December 2015.

Attachment A – Sample Waste Drum Labels



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		Prepared by: Ericka Seiler	
Subject: **FIELD DOCUMENTATION**		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting field activities.

2.0 SCOPE AND APPLICABILITY

Documents presented within this procedure (or equivalents) shall be used for all field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 PROJECT PLANNING

3.1 SITE LOGBOOK

3.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- Date of field logbook entries.
- All field personnel present and their affiliation.
- Weather conditions.
- Site activities.
- Arrival/departure of site visitors.
- Time and date of KGS training (i.e., safety briefings, etc.).
- Arrival/departure of equipment.
- Equipment serial numbers.
- Time and date of equipment calibration.
- Equipment inspection.
- Activities performed and any deviations from procedures or plans..
- Start and/or completion of sampling, borehole, trench, monitoring well installation, etc.
- Sample shipping/pickup information.
- Health and Safety issues.

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries should be made for every day that onsite activities take place. Upon completion of the fieldwork, the site logbook must become part of the project's central file on most projects.

The following information must be recorded on the cover of each site logbook:

- Project name,

- Project number,
- Sequential book number,
- Start date, and
- End date.

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 3.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated.

3.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

3.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook. The field notebook will contain similar information to the field logbook, with the exception that it will be specific for a particular project activity.

3.3 FIELD FORMS

Example field forms are listed in Section 3.5 of this SOP. Forms may be altered or revised for project specific needs contingent upon Project Manager approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

3.3.1 Sampling, Request for Analysis, and Field Test Results

3.3.1.1 Sample Logs Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded

on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

3.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels are typically supplied from the laboratory subcontractor.

3.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (CoC) Record is a form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One copy of the completed CoC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory.

If the sample coolers are being shipped to the laboratorwy, the original CoC form shall be placed inside a large sealable plastic bag and taped inside the lid of the shipping cooler. If multiple coolers are to be shipped, each cooler will have a dedicated CoC form for those samples it contains. Multiple coolers **will not** be shipped on a common CoC form and/or under a common air bill. Each cooler will have a dedicated air bill. An example of a CoC Record form is provided as Attachment C.

Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed CoC form; any discrepancies between the sample labels and CoC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the contractor Project Manager and/or Project Chemist. The CoC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

3.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label and is part of a chain-of-custody process used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The CoC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples. CoC seals may be available from the laboratory; these seals may also be purchased from a supplier.

3.3.1.5 Geochemical Parameters Log Sheet

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

3.3.2 Hydrogeological and Geotechnical Forms

3.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements conducted at a site.

3.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

3.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

3.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organic vapors are monitored (using a PID or FID) on cores, samples, cuttings from the borehole, or breathing zone, these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

3.3.2.5 Monitoring Well Construction Form

A Monitoring Well Construction Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

3.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

3.3.2.7 Monitoring Well Development Record

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

3.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents, if required by the project. The Field Operations Leader (FOL) is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List may be used during both the planning and field effort to assure that all necessary tasks are planned for and completed.

3.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring, or test equipment is necessary to

assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

3.4 FIELD REPORTS

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by Project Management.

3.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports (DARs) may be required by a project and are completed and submitted as described below.

The DAR documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors.

At the end of the shift, the field activity leader must submit the DAR to the FOL for review and filing. The DAR is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

3.4.2 Weekly Status Reports

To facilitate timely review by Project Management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

3.5 SAMPLE FIELD FORMS

Additional field forms provided in Attachment E, consisting of the following:

- Boring/Monitoring Well Construction Log
- Monitoring Well Development Record
- Bedrock Well Development Record
- Monitoring Well Inspection Sheet
- Groundwater Level Measurement Sheet
- Low Flow Low Stress Groundwater Sampling Log
- Sediment-Surface Sampling Log
- Instrument Calibration Log – DO, pH, ORP, Conductivity

- Instrument Calibration Log – Turbidity

4.0 REFERENCES

None.

Attachment A – Sample Site Logbook Entry

13 September 2017 Jane Doe Cloudy, drizzle, breezy, 50s

Objectives: Drill and install monitoring well MW03.

0700 Onsite. Drilling subcontractor on site, setting up.

0705 Conduct Health and Safety Briefing.

0730 Continue with Boring MW3, drilling with HSA and collecting split spoon samples.

0735 Collect SITE1SOMW33031 from 30 to 31 feet bgs for metals and VOCs.

0800 End boring at refusal (rock?) at 42 feet bgs. Driller getting supplies around to set well in Boring MW3.

0815 Insert well casing (2-inch PVC) with 10 feet of 0.010" slot screen to 41 feet bgs (approximately 1 feet of slough from 41 to 42 feet bgs).

0820 Add one bag of filter sand (NSF 10/20, see picture #12), sand to 38 feet bgs.

0825 Add second bag of sand, sand to 34 feet bgs.

0830 Add third bag of sand, sand to 30 feet bgs.

0835 Add part of fourth bag of sand to 29 feet bgs.

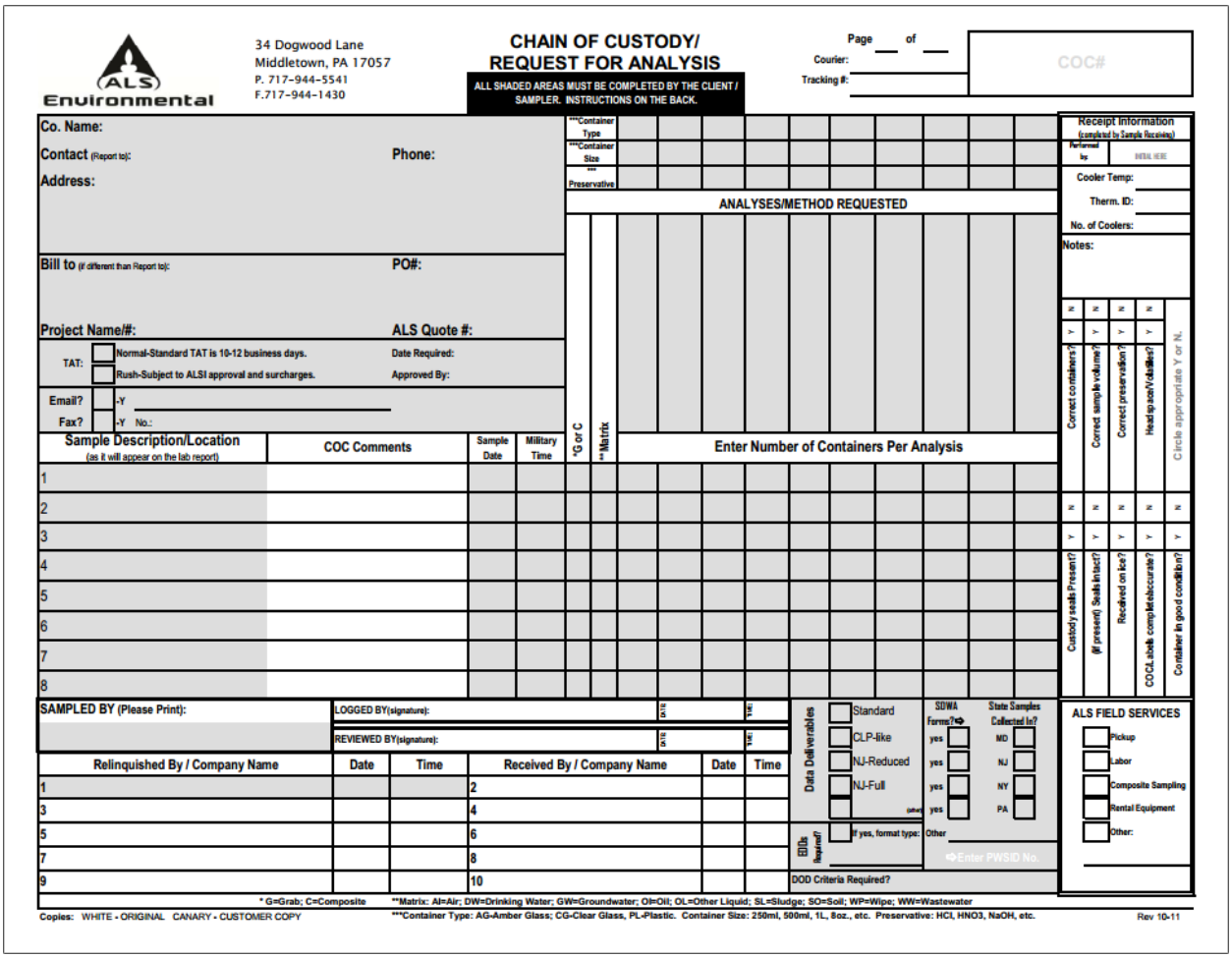
0840 Add bentonite pellets (Benseal, picture #13) (bentonite from 29 feet to 27 feet bgs, hydrate.

0900 Begin to grout well. Mix three bags of Portland cement (see picture #14), with 15 gallons of water, and small amount of powdered bentonite (Benseal, picture #14)…..

Attachment B – Sample Label

Project:		
Site:		
Location:		
Sample No:		Matrix:
Date:	Time:	Preserve:
Analysis:		
Sampled By:		Laboratory:

Attachment C – Sample Chain of Custody Form



ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F.717-944-1430

CHAIN OF CUSTODY/
REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

Page ___ of ___
Courier:
Tracking #:
COC#

Co. Name:
Contact (Report to):
Phone:
Address:
Bill to (if different than Report to):
PO#:
Project Name/#:
ALS Quote #:
TAT: Normal-Standard TAT is 10-12 business days. Rush-Subject to ALSI approval and surcharges.
Date Required:
Approved By:
Email? -Y
Fax? -Y No.:

***Container Type
***Container Size
*** Preservative
ANALYSES/METHOD REQUESTED
*G or C
**Matrix
Enter Number of Containers Per Analysis

Receipt Information (completed by Sample Receiving)
Performed by
INITIAL HERE
Cooler Temp:
Therm. ID:
No. of Coolers:
Notes:

Circle appropriate Y or N.
Correct containers? Y N
Correct sample volume? Y N
Correct preservation? Y N
Headspace/Bubbles? Y N
Custody seals Present? (If present) Seals intact? Y N
Received on ice? Y N
COC/Labels complete/accurate? Y N
Container in good condition? Y N

Sample Description/Location (as it will appear on the lab report)	COC Comments	Sample Date	Military Time
1			
2			
3			
4			
5			
6			
7			
8			

SAMPLED BY (Please Print):
LOGGED BY(signature): DATE TIME
REVIEWED BY(signature): DATE TIME

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1			2		
3			4		
5			6		
7			8		
9			10		

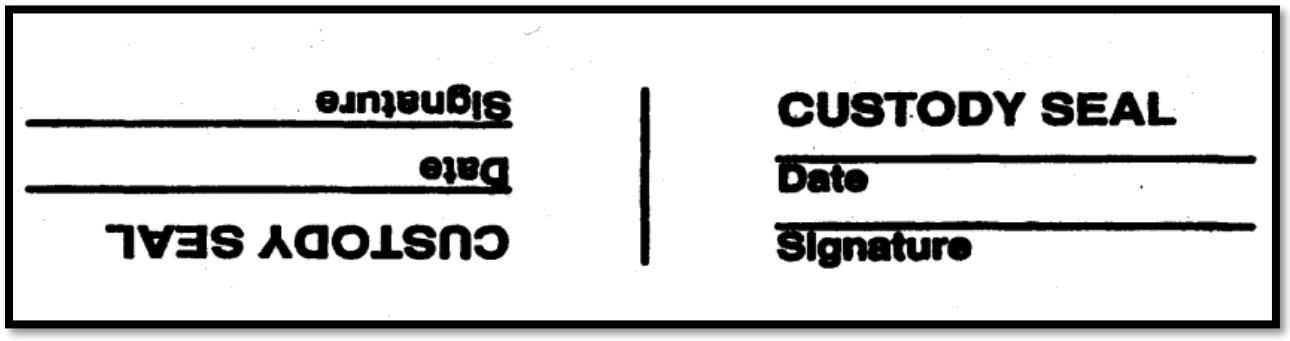
Data Deliverables: Standard; CLP-like; NJ-Reduced; NJ-Full; (other)
EDDs Required? If yes, format type:
SDWA Forms? yes yes yes yes
State Samples Collected In? MD NJ NY PA
Other
Enter PWSID No.
DOD Criteria Required?

ALS FIELD SERVICES
Pickup
Labor
Composite Sampling
Rental Equipment
Other:

* G=Grab; C=Composite
**Matrix: Al=Air; DW=Drinking Water; GW=Groundwater; Oil=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater
***Container Type: AG-Amber Glass; CG-Clear Glass, PL-Plastic. Container Size: 250ml, 500ml, 1L, 8oz., etc. Preservative: HCl, HNO3, NaOH, etc.

Copies: WHITE - ORIGINAL CANARY - CUSTOMER COPY
Rev 10-11

Attachment D – Sample Custody Seal



Attachment E – Sample – Additional Field Forms

SOIL BORING / MONITORING WELL FIELD LOG

MW / SB No.:	Drilling Location:	Project/Client: Site Contact:	Project No:
Contractor:		Site Location:	PID Backgr.(ppm):
Crew:	Date:		PID Lamp (eV):
	Time Start:	Weather:	Surface Elevation (ft above ref. point):
Drill Method:	Time End:	Logged By:	TOC Elevation (ft above ref. point):
Sample Method:		Notes (Surface Condition, Soil Sample Numbers, Soil Drums, etc) :	
Sample Submission:			

Drive / Recovery % ft. in.	Sample No. / Depth	Blow Counts	PID/FID (ppm)	Depth (feet)	Soil Details	Well Details
				0		
				2		
				4		
				6		
				8		
				10		
				12		
				14		
				16		
				18		
				20		
				22		
				24		
				26		
				28		
				30		
				32		
				34		
				36		
				38		

Well Location:

Longitude: Latitude:

Geological Information:

Monitoring Well Construction

- Asphalt
- Well Casing
- Screen (slotted)
- Sand Pack (quartz)
- Bentonite
- Grout
- Sump
- Depth to Groundwater

Soil Characterization

- Transitional Material
- Primarily Sand
- Primarily Silt
- Primarily Clay
- Shale
- Heterogeneous Mixture
- Fill Material

Well Construction Information

Screened Interval (ft bgs):

Well Depth:	Well Dia. (ID/OD):	Stickup Height
Screen length:	Casing length:	Riser length:
Screen size:	Casing Type:	Sand pack Type:
Sump length:	Auger Dia. (ID/OD):	Locked:
Sand Pack:	Bentonite:	Grout:

Comments:

KGS
293 Boston Post Road
Marlborough, MA 01752

MONITORING WELL DEVELOPMENT RECORD

SITE:		WELL IDENTIFICATION NO.		SCREEN LENGTH (FT):	
SITE ADDRESS:		DATE INSTALLED:		CASING ID (IN):	
PROJECT NAME:		DATE DEVELOPED:		DEPTH TO BOTTOM (FT):	
PROJECT NUMBER:		DEVELOPMENT METHOD:		STATIC WATER LEVEL BEFORE (FT).	
PERSONNEL:		PUMP TYPE:		STATIC WATER LEVEL AFTER (FT).	
COMPANY:					

TIME	ESTIMATED SEDIMENT THICKNESS (IN.) Measured from TOC before/during/after	CUMULATIVE WATER VOLUME (GALS).	WATER LEVEL READINGS (FT. BELOW TOC)	TURBIDITY (NTU)	TEMP (C°)	SP. COND. (UNITS____)	DO (mg/L)	pH	ORP (mV)	REMARKS (odor, color, clarity, particulate matter)
	Before During After									

BEDROCK WELL DEVELOPMENT RECORD

SITE:		WELL IDENTIFICATION NO.		TOTAL DEPTH (FT) :	
SITE ADDRESS:		DATE INSTALLED:		CASING ID (IN):	
PROJECT NAME:		DATE DEVELOPED:		DEPTH TO BOTTOM (FT):	
PROJECT NUMBER:		DEVELOPMENT METHOD:		STATIC WATER LEVEL IN FEET BEFORE DEVELOPMENT:	
PERSONNEL:		SUBMERSIBLE PUMP TYPE:		STATIC WATER LEVEL IN FEET AFTER DEVELOPMENT:	
COMPANY:		Turbity Meter Type/ID:		Water Quality Meter Type/ID:	

TIME (every 10 min)	ZONE OF DEVELOPMENT (FT BGS)	CUMULATIVE WATER VOLUME (GALS).	WATER LEVEL READINGS (FT. BELOW TOC)	TURBIDITY (NTU)	TEMPERATURE C	pH	DO	ORP	SP. COND. (UNITS_____)	REMARKS (odor, color, sediment thickness)

4. Move tools sequentially once particular zone is developed

1. Each zone developed until turbidity is constant for 20 min and turb < 5 NTUs
2. Or when stable for 20 min if 5 NTU is not achieved
3. Or when a zone has been developed for min of 1 hr

Well Evaluation Form	
Project Name:	**Date:**
Location:	**Time:**
Tidally Influenced (yes/no):	**Field Crew:**

Field Measurements				
Well ID	**PID Reading (PPM)**	**Depth to Water (feet)**	**Total Well Depth (feet)**	**Comments**

Well Construction Details		
Total Depth (ft)	**Ground Elevation**	**Screened Interval**

Checklist	
Well Material and Diameter:	
Well Casing Reference Point:	
Well ID Tag Present?	
Well Secured?	
Photo Taken?	

Well Condition	
Protective Cover:	
Well Riser Casing:	
Well Pad:	
Other (Posts, Tags, Paint, etc.):	
Standing Water Around Well?	
Dedicated Equipment Present?	
Sediment in Well:	

Groundwater Level Measurement Form

Project Name:	**Date:**
Location:	**Weather:**
Water Level Meter:	**Field Crew:**

Well ID	Time	Depth to Water (feet below TOC)	Total Well Depth (feet below TOC)	Notes

Comments:

Low Flow/Low Stress Groundwater Sampling Log

Project: _____ **Date**: _____ **Sampler:** _____
Location: _____ **Well ID**: _____ **PID:** _____

Start Time: _____ **End Time**: _____
Well Construction: _____
Depth to Water: _____
Water Column: _____
Total Volume Removed (L): _____

Field Testing Equipment

Make	Model	Serial #

Time	Volume Removed (L)	Flow Rate (ml/min)	Depth to Water (ft)	Temp (ºC)	pH (STD)	SPC (mS/cm)	DO (mg/L)	ORP (mg/L)	Turbidity (NTU)	Salinity (ppt)	Color

Acceptance Criteria: < 0.3 ft 3% ± 0.1 3% 10% ± 10mv 10%
2" screen volume 0.163 gal/ft or 616 ml per foot

Signature: _____ Date: _____

Low Flow/Low Stress Groundwater Sampling Low

Sample Collection

Time	Sample ID	Container	# of Bottles	Preservative	Analyses

Comments:

_____

_____

_____

_____

_____

Signature: _____ Date: _____

KOMAN Government Solutions, LLC

Surface Water and Sediment Sampling Log

Project: _____ **Date/Time:** _____

Location: _____ **Sampler:** _____

Sample Location ID: _____

Surface Water/Leachate Seep Information

Type of SW: ( ) Stream ( ) River ( ) Seep

Water Depth:	Dissolved Oxygen (mg/L):
Velocity of Water:	ORP (mV):
Temperature (C):	Specific Conductance (µS/cm):
pH (STD):	Turbidity (NTU):

Sample Observations:

( ) Odor

( ) Color

( ) Other

Field Testing Equipment:

Make Model Serial #

Sediment/Leachate Seep Sediment Information

Sediment Type: ( ) Organic ( ) Gravel ( ) Clay ( ) Silt ( ) Sand ( ) Other _____

Type of Sample Collected: ( ) Discrete ( ) Composite

Sample Observations:

( ) Odor

( ) Color

( ) Other

Samples Collected

Sample ID	Sample Location	Time	Matrix	# of Bottles	Preservative	Analysis

Comments:

Instrument Calibration Log

Project/Site Name:	**Date:**	**Weather:**
Calibrated By:	**Instrument:**	**Serial Number:**

Parameters	**Morning Calibration** Time:_____	**Calibration Temperature ^{o}C**	**Afternoon Calibration Check** Time:_____	**Comments**
Conductivity (µS/cm^{c})				
pH (7)				
pH (4)				
pH (10)				
ORP (mv)				
Dissolved Oxygen (%)				
Zero Dissolved Oxygen (mg/L)				
Barometric Pressure (mmHg)				
Turbidity (0 NTU)				
Turbidity (1 NTU)				
Turbidity (10 NTU)				

Signature: _____ Date: _____

Instrument Calibration Log

Project/Site Name: _____ **Calibrated By**: _____

Instrument/Serial Number	Pre-Cal 0-AM (NTU)	Post-Cal 0-AM (NTU)	Pre-Cal 10-AM (NTU)	Post-Cal 10-AM (NTU)	Pre-Cal 0-PM (NTU)	Post-Cal 0-PM (NTU)	Pre-Cal 10-PM (NTU)	Post-Cal 10-PM (NTU)	Date/ Time(s)

Signature: _____ Date: _____

KOMAN Government Solutions, LLC	STANDARD OPERATING PROCEDURE	Number SOP-F008	Page 1 of 6
		Effective Date 8/15/2017	Revision 0
		Applicability KOMAN Government Solutions	
		Prepared by: Ericka Seiler	
Subject: **NON-RADIOLOGICAL SAMPLE HANDLING**		Approved by: Stephen Deeter	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information regarding sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in separate SOPs.

2.0 SCOPE AND APPLICABILITY

This procedure provides general guidelines on the appropriate analysis-specific containers to be used for all environmental and quality control/quality assurance samples and describes the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 PROJECT PLANNING

To facilitate the collection of representative environmental samples, and to ensure their integrity through the sample handling process, a number of pre-field planning operations are required, including the procurement of laboratory-cleaned sample containers, appropriate sample preservation media, field filtration equipment, and packaging materials, and arrangements for expedited shipping services. Sufficient lead time shall be allowed for a delivery of sample container orders.

3.1 SAMPLE CONTAINERS

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis. Attachment A provides general information on the proper containers (as well as other information). Project specific bottle requirements will be provided by the project chemist or equivalent.

In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds and dissolved gases, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the drilling subcontractor for samples requiring geotechnical analysis.

Once opened, the container must be used at once for storage of the specific sample fraction. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

3.2 SAMPLE PRESERVATION

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration or freezing.

3.2.1 Overview

The general preservation techniques to be used for various target parameters are listed in Attachment A. The project chemist or equivalent will confirm preservation techniques. Reagents required for sample preservation will be added to the sample containers by the laboratory prior to their shipment to the field. Only high purity reagents shall be used for preservation.

In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to around 4 degrees Centigrade (°C). Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with nitric acid ($HN0_3$), whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to around 4°C, whereas high-hazard samples are not cooled.

The Field Operations Leader (FOL) must ensure that a corresponding Safety Data Sheet (SDS) is collected for every hazardous substance, and that all persons using, handling, or disposing of these substances review the appropriate SDS for substances they will handling. The SDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

The following subsections describe the procedures for preparing and adding chemical preservatives.

3.3 FIELD FILTRATION

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- Filter only material that has not been previously preserved. This can be done by collecting an unfiltered portion of a sample in an un-preserved container, then filtering that sample into a preserved container.
- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, either during or immediately after collection. If the sample is particularly turbid, multiple filters may be required.
- The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (because the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).
- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 milliLiters (mL) of sample through the filter and discard prior to sample collection.
- Place the filtered sample directly in the preserved container.
- Alternatively, the filter can be placed in line during immediately before the filtered sample collection where a peristaltic or bladder pump are used (i.e., low flow sampling).

The same general procedures described above will apply. Only the filtered samples will be processed through the inline filter.

3.4 SAMPLE PACKAGING AND SHIPPING

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from unknown waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly).
- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

While, in general, most samples shipped will be environmental; contact the Project Manager and/or the FOL for direction if unsure of the classification for a particular sample. Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

3.4.1 Environmental Samples

Environmental samples are packaged for commercial shipping (e.g., FedEx) as follows:

- Place properly identified sample container, with lid securely fastened, into a sealable plastic bag (i.e., Ziplock™, or similar) and secure the seal.
- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag. Drain plugs on coolers must be taped shut.
- Place sample bottle upright. Place sample bottles with enough room for ice bags to be placed among and around the containers, if icing is required. Place bags of ice (double-bagged) among the containers, along the walls and at the top of the cooler (typically a minimum of 8 pounds of ice for a medium-sized cooler).
- Fill the remaining space with enough cushioning materials such as bubble wrap.
- Seal (i.e., tape or nylon ziptie) the large liner bag.
- The original of the chain-of-custody (CoC) form shall be placed inside a large sealable plastic bag and taped inside the lid of the shipping cooler.
- If multiple coolers are being sent, each cooler will have a dedicated CoC for the samples it contains.
- To minimize trip blanks, all VOC fractions may be placed in a single cooler with the day's trip blank, provided all those samples are listed on the CoC for that cooler.
- Close and seal outside of cooler; signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

4.0 REFERENCES

American Public Health Association, 1981. *Standard Methods for the Examination of Water and Wastewater*, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). *Dangerous Goods Regulations*, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

USEPA, 1984. *Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act*. Federal Register, Volume 49 (209), 26 October 1984, p. 43234.

USEPA, 1979. *Methods for Chemical Analysis of Water and Wastes*. EPA-60014-79-020, USEPA EMSL, Cincinnati, Ohio.

Attachment A – Analytical Information

Environmental Matrix	**Analytical Group**	**Analytical and Preparation Method/SOP Reference**	**Containers** (number, size, type)	**Preservation Requirements** (preservative, temperature)	**Maximum Holding Time**[1] (preparation/analysis)
Groundwater and Surface Water	VOCs	Analysis Method/ SOP: 8260C/02-8260C	2 x 40 milliliter (mL) Volatile Organic Analysis (VOA) vial	Hydrochloric Acid (HCl) pH<2; Cool to 4 ± 2° Celsius (°C); No headspace	14 days
	PFAS	EPA 537-MOD	2 X 60 ml HDPE	Cool to ≤ 4°C	Samples extracted within 14 days and analyzed within 40 days following extraction
Groundwater	SVOCs (SIM) 1,4-Dioxane	Preparation Method/ SOP: 3510C/09-SV1BNA Analysis Method/SOP: 8270D/02-8270	2 x 1 liter (L) amber glass	Cool to 4 ± 2° C	Samples extracted within 7 days and extracts analyzed within 40 days following extraction
	Metals	Preparation Method/ SOP:3015A/09-3015 Analysis Method/SOP: 6020A/03-6020	1 x 500 mL plastic	Nitric Acid (HNO_3) pH<2	6 months
	Mercury	Preparation Method/ SOP: 7470A/09-PDS-Hg Analysis Method/SOP: 7470A/09-Hg	1 x 500 mL plastic	HCl pH<2; Cool to 4 ± 2° C	28 days
MNA Parameters					
Groundwater	Methane, Ethane, Ethane, Carbon Dioxide (CO_2)	RSK 175	3 - 40 mL VOA vial - Glass w/Teflon-lined lid.	No headspace; pH adjusted at time of collection to <2 with 1:1 HCl; 4°C ± 2°C	No criteria (14 Days - Laboratory Recommended)

Environmental Matrix	**Analytical Group**	**Analytical and Preparation Method/SOP Reference**	**Containers** (number, size, type)	**Preservation Requirements** (preservative, temperature)	**Maximum Holding Time**[1] (preparation/analysis)
	Anions	Preparation Method/ SOP: NA Analysis Method/SOP: 9056A/04-ANION2	1 x 250 mL plastic	Cool to 4 ± 2° C	28 days
	Sulfide	Preparation Method/ SOP:NA Analysis Method: SM 4500-S^{2-}/04-S	2 x 250 mL amber glass	Zinc acetate/Sodium hydroxide (NaOH) pH<2, Cool to 4±2˚C	7 days
	Ammonia	Preparation Method/ SOP:NA Analysis Method: ASTM D3695/04-NH3IC	1 x 250 mL plastic	Sulfuric acid (H_2SO_4) pH<2; Cool to 4 ± 2° C	28 days
	Inorganics (Alkalinity)	Preparation Method/ SOP:NA Analysis Method: SW846 2320B 2011/04-ALK2	1 x 250 mL amber glass	Cool to 4 ± 2° C	14 days
	Inorganics (TDS)	Preparation Method/ SOP: NA Analysis Method: SM-2540C 2011/04-TSS	1 x 250 mL amber glass	Cool to 4 ± 2° C	7 days
	TOC/DOC	Preparation Method/ SOP: NA Analysis Method: SW846 9060A/07-TOC	1 x 250 mL amber glass	HCl pH<2; Cool to 4 ± 2° C	28 days
	Inorganics (pH)	Preparation Method/ SOP: NA Analysis Method: 9040C/04-pHW	1 x 250 mL plastic or glass	Cool to 4 ± 2° C	Analyze Immediately
Sediment	Mercury	SW-846 7471A	1 – 4 ounce jar	Cool to 4 ±2 °C	28 days to analysis

(1) Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

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		Effective Date 15 October 2017	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Robert Gregory	
Subject: **PFAS SAMPLING**		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this document is to provide methods, procedures, and guidance for sampling of Per- and Polyfluoroalkyl Substances (PFAS) analysis. Personnel performing PFAS sampling should refer to the appropriate media sampling SOP (e.g., soil, groundwater, sediment, surface water, etc.).

2.0 SCOPE AND APPLICABILITY

This procedure is applicable for sampling efforts for PFAS and, for the most part, are independent of media sampled or the sampling method.

3.0 RESPONSIBILITIES

Personnel performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e., calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

4.0 PROCEDURE

This set of procedures outlines the general steps for collection of samples consistent with the approach for conventional sample collection. Personnel performing PFAS sampling should refer to the appropriate media sampling SOP (e.g., soil, groundwater, sediment, surface water, etc.).

In acknowledgement of the widespread presence of PFAS in the environment (e.g., common household items, packaging, clothing, waterproof paper and pens, etc.) as well as their persistence, significant additional precautions must be taken by sampling personnel to avoid field cross-contamination of environmental samples during PFAS sampling efforts, as follows:

- Sample personnel should not use Post-it Notes® - style adhesive paper products at any time during sample handling, or mobilization/demobilization.
- Sample personnel should wear only old, well laundered (at least six washings since purchase) clothing.
- Sample personnel should not wear water resistant clothing prior to or during sample collection. Tyvek®-style protective clothing must not be worn during sample handling.
- Nitrile glove must be worn at all times while collecting and handling samples.
- Many food and snack products are packaged in wrappers treated with perfluorochemicals. Therefore, hands will be thoroughly washed after handling fast food, carryout food, or snacks.
- Pre-wrapped food or snacks (such as candy bars, microwave popcorn, etc.) must not be in the possession of the sampling personnel during sampling.
- Blue ice must not be used to cool samples or be used in sample coolers.

The following table provides a more detailed summary of items that are likely to contain PFAS and therefore should not be used by sampling teams during sampling efforts. In addition, the

table provides suggestions for items allowable for use as alternatives to items potentially containing PFAS.

Category	Prohibited Items	Allowable Items
Pumps and Tubing	Polytetrafluoroethylene (PTFE), Teflon®, and other fluoropolymer containing materials. Grundfos™ submersible electric pumps contain Teflon®, and therefore should not be used for purging or sampling.	High-density polyethylene (HDPE), low density polyethylene (LDPE), or silicone tubing. Peristaltic pump or stainless-steel submersible pump (i.e., Proactive Mega-Monsoon 12-volt electric, SamplePro bladder pump, etc.).
Decontamination	Decon 90 Liquid Detergent.	Alconox® or Liquinox®, potable water followed by deionized rinse.
Sample Storage and Preservation	LDPE or glass bottles, PTFE-or Teflon®-lined caps, chemical ice packs.	Laboratory-provided sample container - *preferred* or HDPE bottles, regular ice.
Field Documentation	Waterproof/treated paper or field books, plastic clipboards, Sharpie®-type markers, Post-It® and other adhesive paper products.	Plain Paper, metal clipboard, pens.
Clothing	Clothing or boots made of or with Gore-Tex™ or other synthetic water resistant and/or stain resistant materials, coated Tyvek® material.	Synthetic or cotton material, previously laundered clothing (preferably previously washed greater than six times) without the use of fabric softeners.
Personal Care Products (for day of sample collection)	Cosmetics, moisturizers, hand cream and other related products.	Sunscreens: Alba Organics Natural Yes to Cucumbers Aubrey Organics Jason Natural Sun Block Kiss My Face Baby-safe sunscreens (‘free’ or ‘natural’) Insect Repellents: Jason Natural Quit Bugging Me Repel Lemon Eucalyptus Herbal Armor California Baby Natural Bug Spray BabyGanics Sunscreen and Insect Repellents: Avon Skin So Soft Bug Guard-SPF 30.
Food and Beverage	Pre-packaged food, fast food wrappers or containers.	Bottled water or hydration drinks.

5.0 REFERENCES

U.S. Environmental Protection Agency, 2016. *Technical Advisory-Laboratory Analysis of Drinking Water Samples for Perfluorooctanoic Acid (PFOA) Using EPA Method 537 Rev. 1.1*. EPA 815-B-16-021. September.

U.S. Navy Facilities Engineering Command, 2017. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)*. September Update.

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		Effective Date 6/18/2018	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Robert Gregory	
Subject: **GLOBAL POSITIONING SYSTEM MEASUREMENTS**		Approved by: Stephen Deeter	

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1.0 PURPOSE

Global Positioning System (GPS) surveying at the field site is used to estimate position of planned locations in the field and to record surface and subsurface sampling locations as well as other surface and subsurface physical feature (e.g., roads, buildings, waterways, etc.) locations and elevations.

2.0 SCOPE AND APPLICABILITY

The procedures described herein are applicable to all GPS surveying.

3.0 GPS SURVEYING

3.1 Equipment

The selection of the appropriate GPS unit will be based on site-specific conditions (satellite configuration, availability of fixed or portable power supplies, etc.) in addition to the technical project requirements (e.g., accuracy) described in the approved project planning documents.

GPS equipment capable of achieving measurement precision of equal to or less than the project-specified accuracy (See Section 3.4) without correction (e.g., Trimble GeoXH) will be used. GPS equipment should collect data such that post-processing of spatial data can be performed to increase measurement precision, if needed. The equipment will be operated in accordance with manufacturer's specifications, operations manual, and generally accepted surveying practices. The assigned field team must review the instrument-specific operation manual before initiating any field measurements.

Surveying equipment will be field-verified each day before beginning surveying by establishing the coordinates of a known location (e.g., temporary benchmark) using the GPS unit. The benchmark identification (or description) and measured coordinates will be recorded in the survey logbook.

3.2 Survey Points

GPS equipment will be used to record the grid corner and center-point coordinates, that will be marked for future reference during the investigation. GPS will be used to record other pertinent site feature data, for example the margins and elevation of waste piles, pit boundaries, etc. Prior to collecting the center-point sampling location coordinates, each location will be marked with a survey flag. The sample location ID will be recorded on each survey flag. Sample locations will be measured from the center of the grid cell or borehole. For each GPS location recorded, an identifier and the coordinates will be stored in the data logger.

If the coordinates at a survey location cannot be determined because of the presence of tree cover or other obstacles which prohibit adequate signal reception, coordinates will be obtained at a minimum of two alternate locations (offsets) close to the original survey location. The distance and bearing from each of the alternate locations to the original survey location will then be determined using a measuring tape and compass.

3.3 Coordinate Systems

GPS measurements are typically recorded in the UTM coordinate system. Similarly, the horizontal datum will typically be the North American Datum of 1983 (NAD83) and the vertical

datum will typically be the North American Vertical Datum of 1988 (NAVD88). The site-specific grid will be referenced to known National Geodetic Survey (NGS) benchmarks, if possible. Project-specific planning documents should be reviewed to determine if special requirements are in effect.

3.4 Required Accuracy

At a minimum, surveyed location coordinates will be determined to an accuracy of ±0.5 foot. Vertical elevations measured by GPS are suspect due to limited system accuracy. Accuracy will be assessed using the Federal Geographic Data Committee (FGDC) Geospatial Positioning Accuracy Standards. Data may be post- processed to increase accuracy, if required.

4.0 DOCUMENTATION

The field team is responsible for documenting all survey measurements. A complete and accurate record correlating the sample identification numbers (IDs) to the instrument assigned station IDs will be kept in the field logbook. The observations and data will be recorded with waterproof ink in a permanently bound weatherproof field logbook with consecutively numbered pages, and on field data sheets as applicable. Upon completion of the field effort, the electronic record will be downloaded from the instrument, correlated with the sample IDs, and uploaded into the project database.

5.0 REFERENCES

Federal Geographic Data Committee (FGDC) Geospatial Positioning Accuracy Standards.

https://www.fgdc.gov/resources/download-geospatial-standards

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		Effective Date 6/18/2018	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Robert Gregory	
Subject: **INVESTIGATION DERIVED WASTE MANAGEMENT**		Approved by: Stephen Deeter	

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1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance and methods that are used for the handling, management, and disposal of investigation derived waste (IDW) encountered or generated during environmental activities. This SOP gives descriptions of equipment, field development procedures, field data collection, and personnel responsibilities.

2.0 SCOPE AND APPLICABILITY

The procedures described herein are applicable to many types of IDW. The Project Manager or Field Manager have the overall responsibility for implementing this SOP. They will be responsible for assigning appropriate environmental staff to implement this SOP and for ensuring that all procedures are followed.

3.0 RESPONSIBILITIES AND QUALIFICATIONS

All personnel performing these procedures are required to have the appropriate health and safety training. Personnel overseeing the handling and disposal of IDW will have IDW management knowledge and experience, or will work under the direct field supervision of knowledgeable and experienced personnel. Personnel will perform this work in accordance with the project-specific health and safety (H&S) planning and work plan documents.

4.0 EQUIPMENT LIST

The following materials and equipment may be needed for IDW management:

- Personal protective equipment (PPE) as outlined in the H&S planning document.
- Decontamination equipment and supplies (e.g., wash/rinse tubs, brushes, non-phosphate detergent, plastic sheeting, paper towels, sponges, baby wipes, garden-type water sprayers, large plastic bags, potable water, distilled water and/or deionized water.
- Department of Transportation (DOT)-rated 55-gallon drums or other approved containers for containing soil cuttings, decontamination water, and formation water.
- Drum/bung wrench and drum funnel.
- Heavy equipment forklift or vehicle with drum grappler (as necessary).
- Laboratory-supplied sample containers.
- Photoionization detector (PID) or flame ionization detector (FID).
- Wood pallets (as necessary).
- Non-porous (e.g., stainless steel) shovels.
- Polyethylene tanks (as necessary).
- Field notebook and waterproof and permanent marking pens.

5.0 PROCEDURES

It is anticipated that typically both non-liquid and liquid IDW will be generated or encountered during field activities. IDW generated during a field investigation may be expected to include:

- Soil cuttings and other soil wastes generated during sampling.
- Well development and purged water.
- Wash and rinse waste from decontamination activities.
- Used PPE and other non-soil solid wastes.

As applicable, field activities that generate IDW will be conducted consistent with sustainable practices (e.g., reducing the volume of routine waste or IDW generated by decreasing materials consumption).

If the work plan indicates one or more types of IDW generated at the site will be containerized, this will be accomplished as indicated below.

Prior to beginning the collection of IDW, field personnel must verify that adequate and appropriate containers are available on-site. Separate containers must be available for each waste media. Solids, liquids, sludges, and spent equipment should never be mixed unless specified in the work plan.

Containers used to store IDW must be properly labeled. Two possible conditions must be considered when labeling IDW containers.

1. Waste characteristics are known to be either hazardous or non-hazardous based on site data; or
2. Waste characteristics are not known.

In situations where the waste characteristics are known, the waste containers should be labeled accordingly as either hazardous or non-hazardous waste and should include the following information:

- Description of waste (e.g., soil cuttings, decontamination water, NAPL, etc.);
- Date(s) when IDW was generated;
- Generator information (i.e., company/organization name, representative name, contact information, address where the waste was generated);
- Drum number as identified on the IDW Inventory Tracking Sheet; and
- United States Environmental Protection Agency (USEPA) identification number and waste code (for hazardous IDW only).

In situations where the characteristics of the IDW are not known the waste containers must be labels with the information above with an additional notification label stating *"Waste Characterization Unknown Pending Analysis".*

Labels should be made of a weatherproof material and completed using a permanent marker resistant to fading in sunlight. Whenever possible, IDW containers should be staged in a shaded area. Additionally, a drum crayon can be used to label the side or top of containers to facilitate identification should a label fall off before shipping.

During waste accumulation, daily inspections of IDW containers and the staging area should be performed to ensure that all containers are labeled, closed, and included on the IDW Inventory

Tracking Sheet prior to leaving the site.

IDW will be placed in appropriately sized containers at the point of generation. Mixing of soil cuttings or water from several different locations may be permissible in order to fill the drums. However, if significantly different chemical signatures are expected between locations, IDW from each location may require separate containers.

When drums or containers are full, or daily activities are completed, the drum lids and rings will be fastened. Full drums or containers will be transported to the designated IDW accumulation area on a regular basis to avoid accumulation of drums or containers at investigation sites for extended periods of time. Appropriate analyses will be evaluated prior to disposal.

5.1 PPE and Disposable Investigation Equipment

The typical plan for managing used PPE and other non-soil solid waste generated during field activities (e.g., sample handling) is to collect it in plastic trash bags and for the material to be disposed of as a solid waste. Potentially contaminated PPE or disposable investigation equipment will be decontaminated prior to placement in the plastic bags or containers, if warranted. Decontamination procedures consist of brushing off, or using small amounts of water to scrub off, gross potential contamination.

5.2 Off-Site Disposal

Disposal of IDW during field activities will be coordinated with the Project Manager and the Client representative prior to the initiation of field activities. If it is necessary for IDW to be disposed of off-site, waste materials will be properly manifested, and off-site disposal/treatment facilities will be solicited and properly vetted. Only Company- and Client-approved facilities will be used. For off-site disposal, a licensed waste hauler is required for transport. All waste must be disposed of in accordance with DOT, Resource Conservation and Recovery Act (RCRA), USEPA, and applicable state requirements. KGS will not sign waste manifests as the generator, unless the Client provides the approval and documentation that KGS may sign the waste manifest on behalf of the client.

6.0 DOCUMENTATION

Documentation of field observations and data will provide information on the activities concluded and also provide a permanent record of field activities. The observations and data will be recorded with waterproof ink in a permanently bound weatherproof field notebook with consecutively numbered pages. At sites where containerized IDW remains at the site for a period of time an IDW Inventory Log should be used.

Project staff are responsible for thoroughly documenting IDW handling and disposal activities and are responsible for documenting the collection, transportation, labeling, and staging or disposition of IDW. The information entered concerning IDW should include the following:

- Project Name.
- Names of personnel.
- Site location.
- Type of activities.

- Date waste generated.
- Boring, well, or site number(s).
- Matrix.
- Type of container(s).
- Estimated volume.
- Disposition of contents.
- Comments (field evidence of contamination [e.g., PID reading, odors]).
- Any variance to procedures described in this SOP.

7.0 REFERENCES

U.S. Environmental Protection Agency (USEPA), 1992. Guide to Management of Investigation-Derived Waste, January.

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		Effective Date 4/10/2018	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Kerk Halberg	
Subject: **PORE WATER SAMPLING**		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide a standardized method for collection of pore water samples from micro push points or mini piezometers. This SOP describes the equipment and operations used for sampling pore water to be evaluated for the presence of contamination or other project specific requirements.

2.0 SCOPE AND APPLICABILITY

Pore water samples will be analyzed for chemical and/or physical parameters that are specific to the technical project objectives as identified in the project planning documents. The data may be used to physically and chemically characterize the site, to assess the potential risks or hazards posed by detected constituents of concern or to initially evaluate the types of remedial actions or measures required to control identified site impacts.

3.0 POREWATER SAMPLING PROCEDURES

3.1 EQUIPMENT

All sampling equipment that may come in contact with samples or sampling surfaces should be constructed of materials that are compatible with the selected target analyses. The following equipment/materials are required for the performance and documentation of the sediment sampling effort:

- Project Plans including APP/SSHP and SAP.
- Micro Push Point Sampler (Henry Sampler).
- Peristaltic Pump and disposable Teflon®-lined tubing - used to purge groundwater through the Push Point sampler for sampling.
- Inline 0.45 micron filters for dissolved metals.
- 3 way sampling valve.
- Laboratory Bottleware.
- Disposable gloves to prevent cross contamination of samples and exposure to chemicals as per APP/SSHP.
- Personal Protective Equipment as per APP/SSHP.
- Sampling Stakes - used to identify pore water sampling location.
- Field Notebook - a bound book used to record progress of sampling effort and record any problems and field observations during sampling.
- Permanent Marking Pen - used to identify sample containers and for documentation of field logbooks and data sheets.
- Decontamination Materials - used to decontaminate the sampler after use.
- Deionized Water - used to rinse cleaning solution from the push point samplers during decontamination.
- Trash Bag - used to dispose of gloves and any other non-hazardous waste generated during sampling.

3.1.1 Sampling Device Description

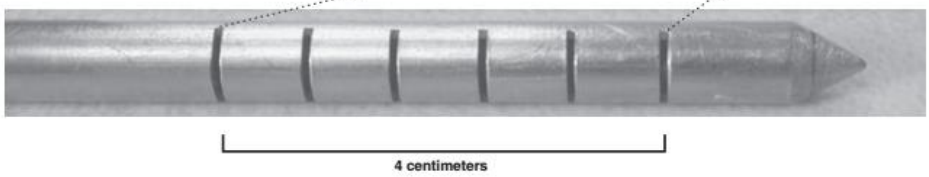
The Henry push point pore water sampling device is a simple, precisely machined tool consisting of a tubular body fashioned with a screened zone at one end and a sampling port at the other. The bore of the push point body sampler is fitted with a guard-rod that gives structural support to

the sampler and prevents plugging and deformation of the screened zone during insertion into sediments. The sampler is made of 316 stainless steel assuring compatibility with most sampling environments. The screened-zone consists of a series of interlaced machined slots which form a short screened-zone with approximately 20% open area.

Pushpoint Sampling for Defining Spatial and Temporal Variations in Contaminant Concentrations in Sediment Pore Water

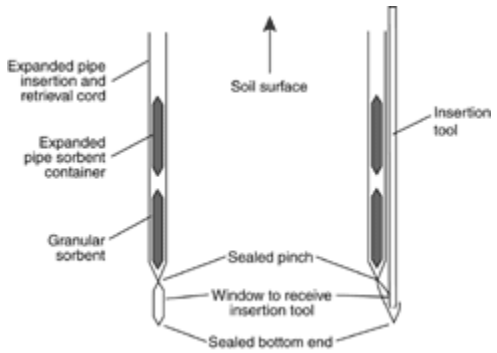
A. **Pushpoint sampler. Rod lengths used were 91 centimeters and 183 centimeters.**

B. **Point head detail. Screen is 4 centimeters wide. Tube diameter is 6.4 millimeters.**

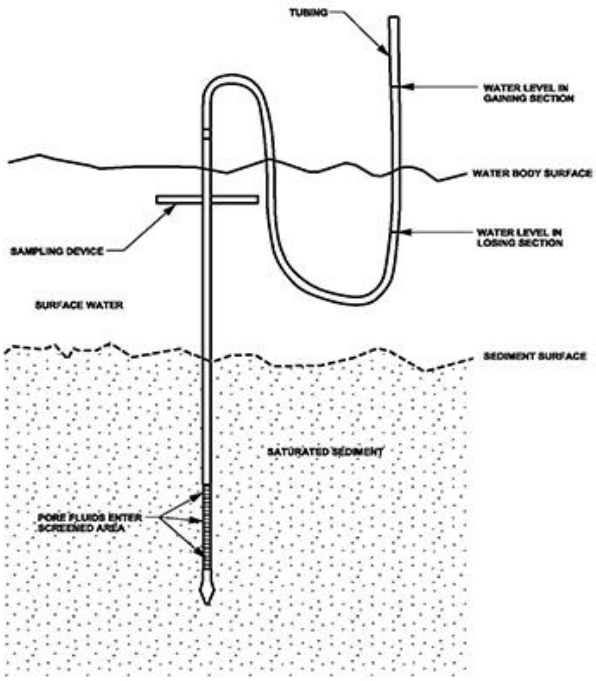


3.2 POREWATER SAMPLING

Operation of the device requires holding the device in a manner that squeezes the two handles towards each other to maintain the guard-rod fully inserted in the push point body during the insertion process. Holding the device in this manner, push the sampler into the sediments to the desired depth using a gentle twisting motion. When the desired depth is reached (or you hit refusal) remove the guard-rod from the push point body without disturbing the position of the deployed sampler. Once the guard-rod has been removed from the sampler, it SHOULD NOT be reinserted into the device until the bore of the push point has been thoroughly cleansed of all sand, silt, etc.



Attach a syringe or peristaltic pump to the push point sample-port and withdraw water at a low-flow sampling rate (50-200 ml/min.). The first 20-50 ml of groundwater typically will be turbid. This is the "development" water and should be discarded in accordance with IDW procedures. Once non-turbid aliquots have been withdrawn, representative samples can be collected for on-site and off-site analysis.



3.2.1 Operational Techniques

- The push point sampler can be decontaminated and reused during future events.
- If the screened-zone of the PushPoint becomes plugged while inserted in the sediments, it is frequently possible to hydraulically/pneumatically shock the screened-zone free of adhering material while it is inserted into the sediments. Attach a large-volume (50 ml) syringe to the sampling port. In a quick motion, pull the syringe plunger most of the way back (creating a vacuum) and then immediately release the plunger - the plunger will slam to a neutral position, sending a shock wave through the bore of the push point and may alleviate the problem.
- The push point can also be used as a piezometer to determine the static head of the groundwater and hence, the potential direction of groundwater movement. To do this, a tube is connected to the sample port. A continuous stream of water is established from the syringe (or pump) to the screened-zone by pumping out any air remaining in the sampler and tubing. When the tube is disconnected from syringe, the static water level in the tube will represent the static water level at the depth that the screened-zone occupies. When the tubing is removed, the push point flows like a miniature artesian well.
- When straightening the screened zone it is sometimes helpful to flush out the bore of the device with a cleaning solution and then insert the guard-rod to the area of the bend in the screened-zone. Gently unbend the portion of the screened-zone nearest the rod and carefully advance the rod to the next bend. After the rod has been fully inserted into the screened-zone perform the final screened-zone, straightening until the guard-rod slides freely through it.

- The discharge line will be equipped with either a pinch clamp and/or a 3-way valve between the sampling port and the pump inlet. This will prevent water from being drawn back to static levels when connecting inline filers.

3.2.2 Decontamination and Maintenance

The push point sampler will be decontaminated prior to each use following as modified below. Begin decontamination of the micro push point Sampler by thoroughly removing all sand, silt etc. from the guard rod and the exterior of the sampler with a tap water rinse or deionized water. Clean the exterior of the guard-rod and sampler body and screened-zone with a stiff brush and cleaning solution (e.g., Liquinox® and water). Connect the cleaning adapter to a "garden sprayer" (with the spray nozzle removed) filled with cleaning solution. Gently insert the screened-zone of the Push Point Sampler into the cleaning adapter, making sure not to bend the screened-zone. Push approximately 300 ml of pressurized cleaning solution through the sampler into an IDW container.

Gently push the guard rod all the way into the bore of the Push Point sampler to dislodge any bridged material. Re-rinse the Push Point sampler with cleaning solution. Follow this with a tap water/and distilled water rinse. Rinse the guard rod with cleaning solution, followed with a tap water rinse and distilled water rinse. Reinsert the guard-rod into the push point sampler and the device is ready for re-use.

Note: before the guard-rod is reinserted into the Push Point Sampler, all small bends in both the guard-rod and in the Push Point Sampler should be removed. Use caution when straightening the screened zone, it is somewhat delicate without the guard-rod inside it and can be broken through repeated bending. It is sometimes helpful when straightening the screened zone to insert the guard rod or the cleaning rod to the area of the bend in the screened zone. Gently unbend the portion of the screened zone nearest the rod and carefully advance the rod to the next bend. After the rod has been fully inserted into the screened zone perform the final screened zone straightening fine-tuning until the guard rod slides freely through it.

3.3 SAMPLING HANDLING

Preserve the samples according to the analytical method, store the samples at 4 degrees Celsius (°C) (+/- 2°C) prior to shipping in accordance with standard sampling protocol.

4.0 ADDITIONAL PORE WATER SAMPLERS

Depending upon project specific details, additional porewater sampling devices may be needed. An example of a common type of porewater is the sediment peeper porewater sampler. Pore water equilibrators or "peepers" are used to obtain vertical profiles of pore water within the sediment column. The pore water equilibrator is designed to allow the collection of discrete water samples at a small spatial resolution by preventing vertical mixing of adjacent water masses. The general principle of this method involves allowing a volume of deionized (DI), distilled water to come to equilibrium with the sediment pore water in order to determine chemical concentrations.

The peeper consists of a Plexiglas base (77 cm long x 10 cm wide x 2 cm thick) with several cells (7 cm x 1 cm x 1.5 cm) milled into it. A 0.4 µm Nucleopore membrane filter is placed over the cells which have been filled with DI water. A coarse nylon mesh is placed over the

membrane to provide protection. A slotted Plexiglas cover is screwed to the base. Prior to placement in the field, the equilibrators are placed in containers filled with DI water and nitrogen gas is bubbled through the water column to purge O_2 from the containers to avoid aerating the soil in the area of insertion. Field pH will be recorded for all pore water samples. Redox readings will be obtained following all pore water collections.

The peepers are then inserted into the sediment and the chemical species in the pore water diffuse across the membrane until equilibrium is achieved. Equilibration times reported have varied anywhere from 3 to 20 days (Carignan, 1984). According to established literature, two weeks is sufficient time for equilibration. Upon retrieval, the soil-water interface is marked. Samples are withdrawn by a syringe and composited over 2 cm increments. The nutrient analysis data along with published coefficients allow for the calculation of nutrient flux rates from the soil to the overlying water column using Fick's First Law (Carignan, 1984).

Note: One drawback of using this method is the small volume of water collected within each cell.

Laboratory Preparation – For preparation of equilibrators prior to installation in the field you will need:

- equilibrators,
- 0.4 µm membrane filter,
- deionized water,
- power screwdriver,
- Liquinox® detergent,
- protective screen, and
- latex gloves.

Field Deployment and Sample Collection Procedures – For deployment of equilibrators and collection of pore water samples in the field you will need:

- field data book,
- header sheets,
- pre-labeled sample bottles,
- concentrated. H_2SO_4,
- deionized water,
- mallet,
- wax pencil,
- thin sharpies,
- compact pH meter,
- pH 7 and 4 calibration buffers,

- pH strips,
- syringes, and
- latex gloves.

1. Clean equilibrators with Liquinox® soap and rinse with deionized water. Keep equilibrators in horizontal position during preparation. Also wear gloves to avoid possible contamination.

2. Fill equilibrator base with deionized water.

3. Cut Nucleopore 0.4 µm membrane sheets to fit the dimensions of the equilibrator. The membrane (with blue backing still attached) is cut using a blade paper cutter that has been thoroughly cleaned with Liquinox® and rinsed in deionized water. Remove blue backing and cover entire length of water-filled cells. Remove large air bubbles by gently lifting the edges of the membrane and then replacing it on the water surface. Ensure separate pieces of membrane overlap 2 cells.

4. Cut nylon "no-seeum" netting to fit equilibrator and place over membrane.

5. Place faceplate on equilibrator and using a syringe needle punch holes into the membrane where the screw holes should be. Faceplate and matching bottom sections are identified numerically.

6. Screw on faceplate using power screwdriver.

7. Examine assembled equilibrators for any rips in membrane, air bubbles, etc. which may occur during assembly. If errors are found the equilibrator should be disassembled and repaired.

8. Place equilibrator into Plexiglas case containing deionized water. Insert plastic tube into septum at top of container lid. Prior to insertion in the field purge containers for a minimum of 3 hrs with N_2 gas to deplete any air in the cells.

9. Keep equilibrators in oxygen-deficient containers until immediately before insertion into the soil at the sampling site.

10. At the mesocosm site, remove equilibrator from storage/transport container.

11. Drive equilibrator into soil using a block of wood and mallet. Equilibrators should be installed such that at least four cells are above the sediment-water interface.

12. Allow equilibrators to incubate in situ for 2 weeks.

13. Mark sediment-water interface on equilibrator faceplate using a wax pencil.

14. Remove equilibrator and carry in horizontal position to platform for processing.

15. Mark off sampling increments along the equilibrator using the wax pencil.

16. Process cells in the deepest sediment layer first working up into the water column (i.e., 8-10, 6-8, 4-6, 2-4, 0-2, 0-+2, +2-+4). This minimizes the amount of time for oxygen diffuse back into the cells.

17. Pierce the membrane of the cell with the tip of the syringe. Leave the tip in place and sample by drawing carefully into the syringe. Avoid pulling bubbles of air into the sample.

18. Place the tip of the syringe needle onto the bottom of the sample collection bottle and

discharge the contents, keeping the needle tip submerged below the water at all times.

19. Place a small sub-sample of water onto the tip of the calibrated compact pH meter and record pH in the header sheet.

20. Pour approximately one half of the water into another bottle and acidify where appropriate.

21. Place samples in ice chest for transport to the laboratory.

4.1 SAMPLING HANDLING

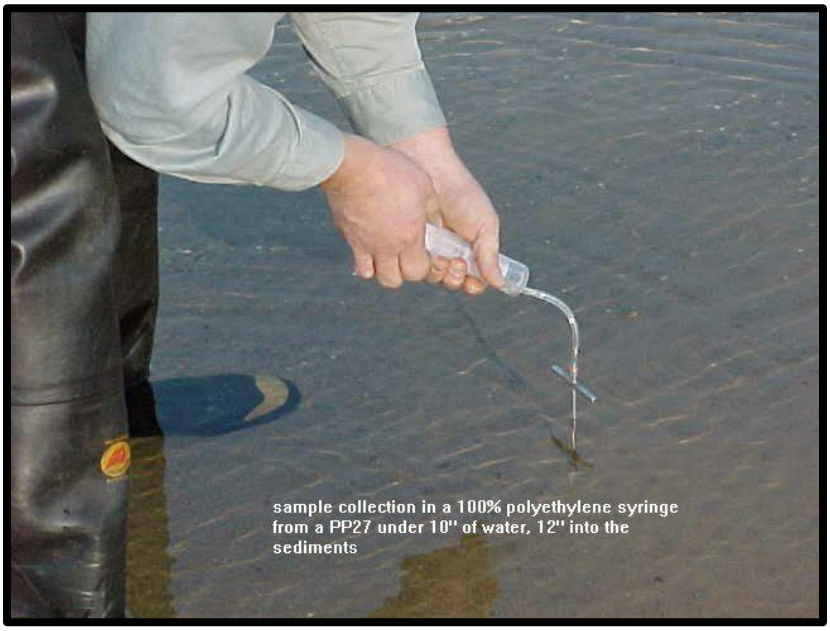
Preserve the samples according to the analytical method, store the samples at 4 degrees Celsius (°C) (+/- 2°C) prior to shipping in accordance with standard sampling protocol.

5.0 REFERENCES

Interstitial water sampling by dialysis: Methodological notes, Carignan, May 1984.

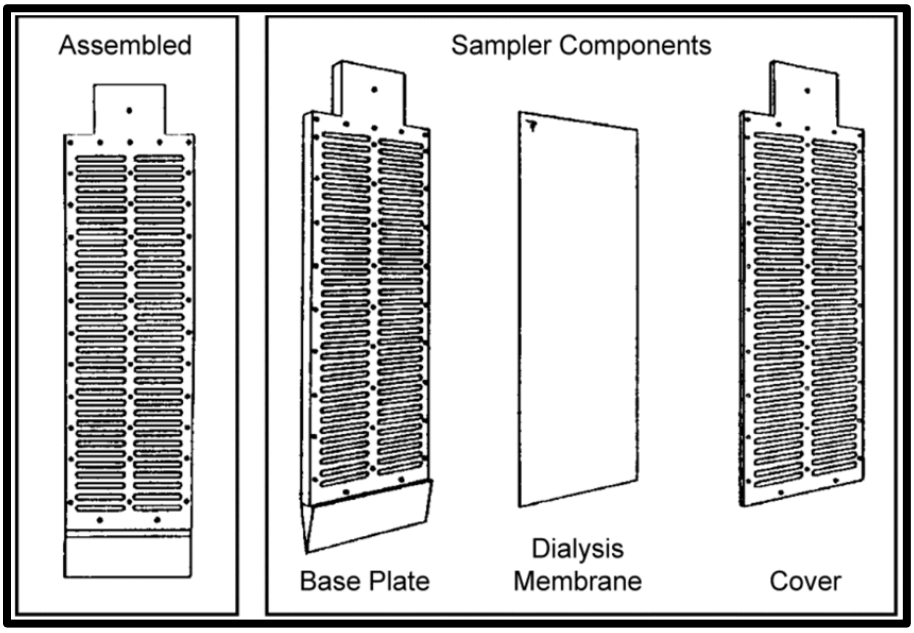
https://aslopubs.onlinelibrary.wiley.com/doi/abs/10.4319/lo.1984.29.3.0667

Collecting a sample from Henry Sampler

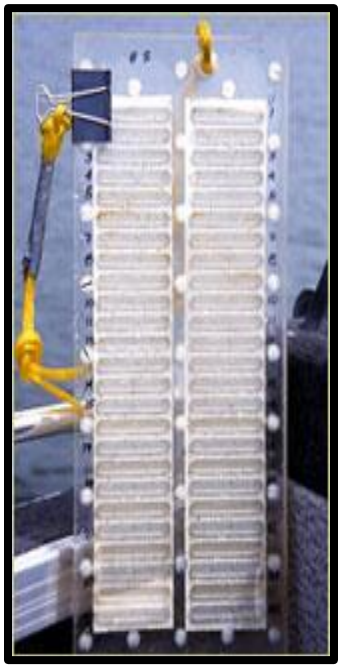


Installation of Henry Direct Push Sampler

Construction of Sediment Peeper Pore Water Sampler



Photograph of Sediment Peeper Pore Water Sampler



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		Effective Date 6/19/2018	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Ericka Seiler	
Subject: **SITE SPECIFIC HEALTH AND SAFETY TRAINING**		Approved by: Stephen Deeter	

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F013 SITE-SPECIFIC HEALTH AND SAFETY TRAINING

1.0 PURPOSE

Personnel who will be performing construction-related, non-intrusive, non-hazardous onsite tasks are not required to have been trained according to U.S. Department of Labor OSHA Standard 29 CFR 1926.65 *Hazardous Waste Operations and Emergency Response.* These workers will have appropriate safety and health training based upon their specific job tasks and activities.

2.0 SCOPE AND APPLICABILITY

The Field Manager, Site Safety and Health Officer/Emergency Coordinator, or other personnel conducting the field sampling and monitoring for contaminants, performing intrusive operations, or performing any site task in which site contaminants may be encountered will be trained as required to meet the U.S. Department of Labor OSHA Standard 29 CFR 1926.65, *Hazardous Waste Operations and Emergency Response,* to qualify as hazardous waste site workers and supervisors. Training will include:

- A minimum of 40 hours of initial offsite instruction
- A minimum of 3 days of actual field experience under the direct supervision of a trained, experienced supervisor
- An 8-hour "refresher" training period annually
- Additional training that addresses unique or special hazards/operational requirements.

Onsite supervisors who are directly responsible for or who supervise employees will receive at least 8 additional hours of hazardous waste operations training for supervisors. Copies of training certificates and dates of attendance for KGS personnel will be available through the Site Safety and Health Officer/Emergency Coordinator upon request.

3.0 PROCEDURES

Prior to entering the Site, personnel will attend a pre-entry orientation session presented by the Site Safety and Health Officer/Emergency Coordinator. Visitors entering designated work areas will be subject to applicable safety and health regulations during field operations at the Site. The Field Manager and/or Site Safety and Health Officer/Emergency Coordinator is responsible for briefing the personnel onsite of potential hazards that may be encountered on the Site, the presence and location of the Site HASP, and emergency response procedures. Visitors will be under the direct supervision of the Field Manager and/or Site Safety and Health Officer/Emergency Coordinator or his/her representative.

At a minimum, the pre-entry orientation session will discuss the contents of this HASP, PPE, potential hazards, and health effects of hazards associated with onsite activities and the potential hazards presented by unearthing unidentified hazardous materials. Personnel will be instructed in emergency procedures, to include onsite communications and implementation of the site-specific contingency plans.

Non-hazardous waste site workers will be medically examined as needed to meet OSHA requirements specific to their job. Hazardous waste site workers must have satisfactorily

completed a comprehensive medical examination by a licensed physician within 12 months (or 24 months, pending physician's approval) prior to the start of site operations. Subcontractors will provide this information in writing to the Project Manager for their workers prior to mobilization onsite. Copies of this information will be kept onsite by the Site Safety and Health Officer/Emergency Coordinator. A licensed physician who is certified in Occupational Medicine by the American Board of Preventative Medicine will review medical surveillance protocol and examination results. Medical surveillance protocols will comply with 29 CFR 1910.120. The content of medical examinations will be determined by the attending physician and will be based upon the guidelines in the *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.* Medical examinations and consultations will be provided for employees covered by this program on the following schedule:

- Prior to field work assignment
- At least annually for employees covered by the program
- At termination of employment
- As soon as possible upon the development of signs or symptoms that may indicate an overexposure to hazardous substances or other health hazards or that an unprotected person has been exposed in an emergency situation
- More frequently if the physician deems such examination necessary to maintain employee health.

An accurate record of the medical surveillance will be maintained for each employee for a period of no less than 30 years after the termination of employment. Records must include at least the following information about the employee:

- Name and social security number
- Physician's written opinions, recommendations, limitations, and test results
- Employee medical complaints related to hazardous waste operations
- Information provided to the physician by the employee concerning possible exposures, accidents, etc.

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		Effective Date 4/10/2018	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Kerk Halberg	
Subject: DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples. The methods and equipment described herein are for collection of surface and subsurface soil samples.

2.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

3.0 SCOPE AND APPLICABILITY

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site- specific conditions or project-specific plans may require adjustments in methodology.

4.0 SOIL SAMPLING PROCEDURES

4.1 EQUIPMENT

The following equipment/materials are typically required for the performance and documentation

of the soil sampling effort:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

4.2 SOIL SAMPLING

There are several methods for the collection of soil samples using DPT drilling. A typical method is discussed in the following section with reference to the Geoprobe® system. Variations of the following method may be conducted in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.
- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.
- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.
- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.
- Place the acetate liner containing the soils in the trough.
- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.
- If specified in project planning documents, field screen the sample with a FID or PID and observe/examine the sample. If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.
- Once sampling has been completed, the hole is backfilled with soil from the core, bentonite chips, or bentonite cement grout, depending upon project requirements.

Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).
- Sampling equipment is decontaminated prior to collecting the next sample.

4.3 SAMPLING HANDLING

Preserve the samples according to the analytical method, store the samples at 4 degrees Celsius (°C) (+/- 2°C) prior to shipping in accordance with standard sampling protocol.

5.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs (Attachment A), and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation. Project requirements may dictate what type of boring log or form is required, as well as soil classification. The most commonly used soil classification system is the Unified Soil Classification System (USCS) and can be applied to mainly unconsolidated materials, refer to KGS SOP-F018 Soil Description.

6.0 SAFETY PRECAUTIONS

- Prior to conducting or overseeing DPT activities, be sure to inspect the Geoprobe® machine and all its hydraulic lines. Ensure that there is no leaking hydraulic fluids and all lines are clear of any obstructions or pinch points.
- Each Geoprobe® machine should have a “kill switch”, which will turn off the machine and any devices running at the time of operation. This should be easily accessible to all personnel and test it to ensure it is operational.
- During operation, secure any loose tools or equipment, as vibration and machine movement can cause them to fall and cause harm to personnel.

7.0 ADDITIONAL SAMPLING MEDIA

Using DPT methods, additional forms of media may be collected, including groundwater and soil gas. This is accomplished by deployment of a temporary screen either into soil or below the groundwater table. Samples are further collected using flexible tubing and portable air/groundwater pumping systems.

8.0 REFERENCES

Drilling Log – ENG FORM 1836, March 1971

http://www.publications.usace.army.mil/Portals/76/Publications/EngineerForms/ENG_FORM_1836.pdf

Continuation of Drilling Log – ENG FORM 1836A, March 1971

http://www.publications.usace.army.mil/portals/76/publications/engineerforms/eng_form_1836a.

pdf

Example Geoprobe Machine

Example Acetate Liner

Example Acetate Liner with Drive Point

Example Acetate Screen Cutter

Portable PID

Portable FID

Attachment A

Soil Boring Log

KOMAN Government Solutions, LLC
SOIL BORING LOG

Project:	Boring No.:
Project No.:	Drilling Co.:
Address:	Driller:
Logger:	Drilling Method:
Date:	Drilling Equip:
Total Boring Depth:	Static Water:

Core Section	Recovery (ft)	Interval (ft)	PID (ppm)	GEOLOGIC LOG	REMARKS

Notes:

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		Effective Date 4/30/2018	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Robert Gregory	
Subject: **SOIL SAMPLING – SURFACE AND SHALLOW DEPTH**		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to describe the equipment and operations used for sampling surface and shallow depth soils. This procedure outlines the methods for soil sampling with routine field operations on environmental projects. Site-specific deviations from the methods presented herein may be required based on procedures described in the project planning documents.

2.0 SCOPE AND APPLICABILITY

Sampling personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects. The Project Leader or an approved designee is responsible for ensuring that performance standards specified by this SOP are achieved.

3.0 PROCEDURES

3.1 Sampling Equipment

Typical surface and shallow soil sampling equipment includes the following list; materials used for non-metallic target constituents are commonly stainless steel, with various plastic compound items used for metallic target constituents:

- Mixing bowl;
- Trowels or spoons;
- Hand auger;
- Core sampler which uses stainless steel or plastic liners (optional);
- Shovel; and
- Appropriate sample containers.

3.2 Decontamination

Before initial use, and after each subsequent use, all sampling equipment must be decontaminated using the procedures outlined in KGS SOP-F005, Decontamination of Field Equipment.

3.3 Sampling Location/Site Selection

The sampling approach and sample design criteria outlined in the project planning documents for each sampling event should be followed. Proposed sample sites should be relocated when conditions dictate - such as natural or artificial obstructions at the proposed sample location (e.g., boulders, asphalt, etc.). The actual sample locations should be documented on a topographic map or site sketch and all sample locations should be photographed, with date and sample identification information recorded.

3.4 Sample Collection and Handling

All boreholes and pits created by the soil sampling process should be filled in with the material removed during sampling unless otherwise specified in the project planning documents. Where a vegetative turf has been established, fill in with native soil or potting soil and replace the turf if practical in all holes or trenches when sampling is completed.

3.4.1 Homogenizing Samples

Homogenizing is the mixing of a sample to provide a uniform distribution of the target constituents. Proper homogenization ensures that the containerized samples are representative of the total soil sample collected. All samples to be composited or split should be homogenized after all aliquots have been combined. DO NOT HOMOGENIZE (MIX OR STIR) SAMPLES FOR VOLATILE COMPOUND ANALYSIS.

3.4.2 Compositing Samples

Compositing is the process of physically combining and homogenizing several individual soil aliquots of the same volume or weight. Compositing samples provides an average concentration of target constituents over a certain number of sampling points.

3.4.3 Splitting Samples

Splitting samples (after preparation) is performed when multiple portions of the same samples are required to be analyzed separately. Fill the sample containers for the same analyses one after another in a consistent manner (e.g., fill client volatile organic compound (VOC) container, fill regulator VOC container, fill client semi-volatile organic compounds (SVOC) container, fill regulator SVOC container, etc.).

3.5 Surface Soil Sampling

Perform the following steps for surface soil sampling:

- Prior to sampling, remove leaves, grass, and surface debris using decontaminated stainless steel or plastic trowel;
- Label the lid of the sample container with an indelible pen or affix the sample label to the side of the jar and tape as to make it impervious to water prior to filling the container with soil. Samples will be identified and labeled in accordance with project planning documents or KGS SOP-F006 Sample Nomenclature;
- Collect surface soil samples with a decontaminated stainless steel or plastic trowel, spoon or hand auger and transfer to a decontaminated stainless steel or plastic bowl for homogenizing. If VOC analyses are to be conducted, fill the appropriate VOC sample containers and then proceed to transfer the appropriate aliquot of soil to the decontaminated bowl for homogenizing;
- Collect samples in the order of volatilization sensitivity. The most common collection order is as follows:

  Volatile organic compounds (VOC),
  Purgeable organic carbon (POC),
  Purgeable organic halogens (POX),
  Total organic halogens (TOX),
  Total organic carbon (TOC),
  Extractable organics,
  Total metals,
  Phenols,

Cyanide,
Sulfate and chloride,
Nitrate and ammonia, and
Radionuclides.

- Immediately transfer the sample into a container appropriate to the analysis being performed (see KGS SOP-F008 Non-Radiological Sample Handling);
- Place the samples in a cooler with ice which must be maintained at approximately 4^{o}C (if appropriate for analyses) for transport to an analytical laboratory;
- Immediately after the sample is collected, record applicable information in the field log book as outlined in KGS SOP-F007 Field Documentation. This information may also be entered on soil sampling log.
- Excess soil sample media shall be placed in the soil boring or pit and filled to grade with native soil or potting soil.
- Decontaminate all sampling equipment (KGS SOP-F005 Decontamination of Field Equipment); and
- Complete the Chain-of-Custody Record and associated documentation (KGS SOP-F007 Field Documentation).

3.6 Shallow Depth Soil Sampling

Perform the following steps to collect shallow depth soil samples:

- Remove leaves, grass, and surface debris that may have contacted the shovel using a decontaminated trowel;
- Excavate soil to the pre-determined sampling depth by using a decontaminated hand auger.
- Periodically, remove the cuttings from the auger;
- When the proper sample depth is reached, remove the hand auger and all cuttings from the hole;
- Lower the decontaminated core sampler or hand auger to the bottom of the hole. When using a core sampler, it must contain a decontaminated liner appropriate for the constituents to be analyzed;
- Mark the sample interval (i.e., one foot above ground level) on the hammer stem or auger;
- Operate the slide hammer on the core sampler to drive the sampler head into the soil, or advance the auger until it is flush with the interval mark at ground level;
- Record weight of hammer, length of slide, blow counts and geologic soil data for all samples collected with a core sampler in the field log book. This information may also be entered on a soil sampling log;
- When the core sampler liner or auger has been advanced the total depth of the required sample, remove it from the bottom of the hole;

- Immediately remove the liner from the core sampler and transfer the sample into a container or bowl for compositing and homogenizing as specified in the project-specific planning documents appropriate to the analysis being performed using a spoon or trowel. Prior to compositing and homogenizing, fill the appropriate aliquot for VOC analysis (if conducted) and then composite and homogenize;
- Immediately transfer the sample into a container appropriate to the analysis being performed (see KGS SOP-F008 Non-Radiological Sample Handling);
- Place the samples in a cooler with ice which must be maintained at approximately 4^{o}C (if appropriate for analyses) for transport to an analytical laboratory;
- Immediately after the sample is collected, record applicable information in the field log book as outlined in KGS SOP-F007 Field Documentation. This information may also be entered on soil sampling log.
- Excess soil sample media shall be placed in the soil boring or pit and filled to grade with native soil or potting soil.
- Decontaminate all sampling equipment (KGS SOP-F005 Decontamination of Field Equipment).
- Complete the Chain-of-Custody Record and associated documentation (KGS SOP-F007 Field Documentation).

3.7 Abandonment Procedures

Abandon boreholes and fill to grade by filling in with the material removed for sampling or clean fill (i.e., potting soil). Project planning documents should be reviewed to determine of other procedures are required for abandonment of sampling holes.

4.0 REFERENCES

United States Environmental Protection Agency (EPA). 1989. Soil Sampling Quality Assurance User's Guide. EPA/600/8-89/046.

EPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4. November

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		Effective Date 4/30/2018	Revision 0
		Applicability KOMAN Government Solutions, LLC	
		Prepared by: Robert Gregory	
Subject: **PRIVATE AND WATER SUPPLY WELL SAMPLING**		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this procedure is to describe the equipment and operations used to collect samples representative of potable private wells and public water supply wells. The procedures are designed to reduce the bias of system related variables (pumps, piping, holding tanks, etc.).

2.0 SCOPE AND APPLICABILITY

Potable water supply investigations are usually conducted as part of a larger investigation such as a spill, leaking tanks, nearby contaminated site, etc. However, an investigation may be conducted independently of a potential contamination source. Potable water supply investigations may include collecting samples directly from public supply wells, distribution systems, private residential wells, etc.

3.0 GENERAL

Special procedures apply when a sample is collected from a private or public potable water supply. All residents will be contacted prior to sampling. At residence, identify yourself and interview the property owner for general well information including: well location, well depth, age, past sample results, holding tank capacity, if water filtration or conditioning unit is used and any other pertinent information. Investigators should always obtain the following information from the residents and/or owners in the event contaminants are detected in the sample:

- Resident's and/or owner's name;
- Resident's and/or owner's mailing address; and
- Resident's and/or owner's home and work telephone numbers.

The contact information is required in order that the residents or water supply owner/operators can be informed of the need/schedule of sampling and to receive the results of the sampling program.

4.0 SAMPLING SITE SELECTION

The following should be considered when choosing the location to collect a potable water sample:

- Taps selected for sample collection should be supplied with water from a service pipe connected directly to a water main in the segment of interest.
- Whenever possible, choose the tap closest to the water source, and prior to the water lines entering the residence, office, building, etc., and also prior to any holding, pressurization or treatment filter systems or tanks.
- The sampling tap must be protected from exterior contamination associated with being too close to a sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collection procedure because it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. If the tap is too close to the ground for direct collection into the appropriate container, it is acceptable to use a smaller (clean) container to transfer sample to a larger container. The smaller container should be made of glass or stainless steel or other material appropriate for

the target constituent list.

- Leaking taps that allow water to discharge from around the valve stem handle and down the outside of the faucet or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations.
- Disconnect any hoses, filters, or aerators attached to the tap before sampling. These devices can harbor a bacterial population if they are not routinely cleaned or replaced when worn or cracked.
- Taps where the water flow is not constant should be avoided because temporary fluctuation in line pressure may cause clumps of microbial growth that are lodged in a pipe section or faucet connection to break loose. A smooth flowing water stream at moderate pressure without splashing should be used. The sample should be collected without changing the water flow. It may be appropriate to reduce the flow for the volatile organic compounds aliquot to minimize sample agitation.

Occasionally, samples are collected to determine the contribution of system related variables (e.g., transmission pipes, water coolers, water heaters, holding tanks, pressurization tanks, etc.) to the quality of potable water supplies. In these cases, it may be necessary to ensure that the water source has not been used for a specific time interval (e.g., over a weekend or a three- or four-day holiday period). Sample collection may consist of collecting a sample of the initial flush, collecting a sample after several minutes, and collecting another sample after the system being investigated has been completely purged.

When sampling for bacterial content, the sample container should not be rinsed before use because of possible contamination of the sample container or removal of any dechlorinating agents (if used). When filling any sample container, care should be taken that splashing drops of water from the ground or sink do not enter into either the bottle or cap.

When sampling at a water treatment plant, samples are often collected from the raw water supply and the treated water after chlorination.

5.0 WELL PURGING

Well purging is the process of removing stagnant cold water prior to sample collection. For potable private water supply sampling, it is recommended to purge the system for at least 15 minutes to remove stagnant water volumes from the well piping to the sample intake location. For municipal supply wells that run continuously, no purging is required other than opening a valve and allowing it to flush for a few minutes. In either circumstance, the field team must coordinate with the well/property owner to determine an appropriate location for the discharge of potentially a large volume of water.

6.0 WELL SUPPLY SAMPLING METHODOLOGY

Samples should be collected following purging from a valve or cold water tap as near to the well as possible and preferably prior to any storage/pressure tanks or physical/chemical treatment system, if present.

- The sample should be collected from a tap or spigot located at or near the well head or pump house and before the water supply is introduced into any storage tank or treatment

unit. Remove any aeration or sediment trap device from the tap prior to sample collection.

- Purge the system for a minimum of 15 minutes.

7.0 REFERENCES

USEPA, 2013. Field Branches Quality System and Technical Procedures - Potable Water Supply Sampling (SESDPROC-305-R3). Region 4. May.

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		Prepared by: Robert Gregory	
Subject: **MONITORING WELL INSTALLATION AND DEVELOPMENT**		Approved by: Stephen Deeter	

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1.0 PURPOSE

The purpose of this procedure is to describe the equipment and operations used to install monitoring wells that will provide high quality samples, will be constructed properly to last the duration of the project and to ensure the well will not serve as a conduit for contaminants to migrate between aquifers.

2.0 SCOPE AND APPLICABILITY

Site geologist personnel are responsible for performing the applicable tasks and procedures are to be used for all permanent and temporary monitoring wells installed for collecting ground water samples for analysis. The Project Geologist or an approved designee is responsible for ensuring that performance standards specified by this SOP are achieved.

3.0 PERMANENT MONITORING WELLS – DESIGN CONSIDERATIONS

The design and installation of permanent monitoring wells involves drilling into various types of geologic formations that exhibit varying subsurface conditions. Designing and installing permanent monitoring wells in these geologic environments may require several different drilling methods and installation procedures. The selection of drilling methods and installation procedures should be based on field data collected during a hydrogeologic site investigation and/or a search of existing data. Each permanent monitoring well should be designed and installed to function properly throughout the duration of the monitoring program. When designing monitoring wells, the following should be considered:

- Short-and long-term objectives;
- Purpose(s) of the well(s);
- Probable duration of the monitoring program;
- Contaminants likely to be monitored;
- Types of well construction materials to be used;
- Surface and subsurface geologic conditions;
- Properties of the aquifer(s) to be monitored;
- Well screen placement;
- General site conditions; and
- Potential site health and safety hazards.

Each of the above considerations can be expanded into many subtopics depending on the complexity of the project. In designing permanent monitoring wells, the most reliable, obtainable data should be utilized. Once the data have been assembled and the well design(s) completed, a drilling method(s) has to be selected. The preferred drilling procedures for installing permanent monitoring wells are those that temporarily case the borehole during drilling and the construction of the well (e.g., hollow-stem augers and sonic methods). However, site conditions may not always be amenable to using these methods. When this occurs, alternate methods should be selected that will perform the job equally as well. The following summary of

methods and procedures for designing and installing monitoring wells describes the different aspects of selecting materials, drilling boreholes, and installing monitoring devices.

3.1 Drilling Methods

The drilling method is generally specified in project planning documents. Various drilling methods are presented below. In all cases, the proper field quality assurance/quality control (QA/QC) procedures should be initiated before and during drilling to minimize the potential for contamination. These QA/QC procedures may include, but are not limited to, sampling and analyzing of all drilling materials such as drilling muds, filter sand, bentonite pellets, grouts, and any potable water introduced during drilling.

3.3.1 Hollow-Stem Auger

This type of auger consists of a hollow, steel stem or shaft with a continuous, spiraled steel flight, welded onto the exterior stem. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, whereupon the spiral flights transport the cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring well can be installed inside of hollow-stem augers with little or no concern for the caving potential of the soils and/or water table. However, retracting augers in caving sand conditions while installing monitoring wells can be extremely difficult or impossible, especially because the augers have to be extracted without being rotated. If caving sands exist during monitoring well installations, a drilling rig must be used that has enough power to extract the augers from the borehole without having to rotate them. A bottom plug, trap door, or pilot bit assembly can be fastened onto the bottom of the augers to keep out most of the soils and/or water that have a tendency to clog the bottom of the augers during drilling. Potable water (analyzed for constituents of concern) may be poured into the augers (where applicable) to equalize pressure so that the inflow of formation materials and water will be held to a minimum when the bottom plug is released. Water-tight center plugs are not acceptable because they create suction when extracted from the augers. This suction forces or pulls cuttings and formation materials into the augers, defeating the purpose of the center plug. Augering without a center plug or pilot bit assembly is permitted, provided that the soil plug, formed in the bottom of the augers, is removed before sampling or installing well casings. Removing the soil plug from the augers can be accomplished by washing out the plug using a side discharge rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. The type of bottom plug, trap door, or pilot bit assembly proposed for the drilling activity should be approved by a senior field geologist prior to drilling operations. Boreholes can be augered to depths of 150 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

3.3.2 Solid-Stem Auger

This type of auger consists of a solid stem or shaft with a continuous spiraled steel flight, welded on the outer side of the stem, connected to an auger bit and when rotated transports cuttings to the surface. This auger method is used in cohesive and semi-cohesive soils that do not have a tendency to collapse when disturbed. Boreholes can be augered to depths of 200 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 150 feet.

Both of the previously discussed auger methods can be used in unconsolidated soils and semi-consolidated (weathered rock) soils, but not in competent rock. Each method can be employed without introducing foreign materials into the borehole such as water and drilling fluids, minimizing the potential for cross contamination. Minimizing the risk of cross contamination is one of the most important factors to consider when selecting the appropriate drilling method(s) for a project.

3.3.3 Sonic Methods.

These methods alternately advance concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string is removed with a core of drill cuttings while the outer string remains to hold the borehole open. The cuttings can be removed nearly intact from the inner casing for examination of stratigraphy prior to disposal. Because there are no auger flights to increase the drill stem diameter, the quantity of cuttings removed from the hole is minimized as compared to hollow stem augering. Smearing of the formation materials on the borehole walls is reduced as well. This drilling method is useful in a variety of materials, from flowing sands to heavily consolidated or indurated formations.

In flowing sands, the drill casings can be filled and/or pressurized with potable water to prevent excess entry of formation materials into the drill string. The same QA/QC requirements for sampling of material introduced to the borehole apply as in other drilling methods. Because the amount of water introduced into the borehole can be significant, an approximation of the water used in the drilling process should be logged for use in estimating appropriate well development withdrawal.

Sonic drilling allows a larger diameter temporary casing to be set into a confining layer while drilling proceeds into deeper aquifers. This temporary casing is then removed during the grouting operation. In many cases this will be acceptable technique. However, the level of contamination in the upper aquifer, the importance of the lower aquifers for drinking water uses, the permeability and continuity of the confining layer, and state regulations should be taken into account when specifying this practice as opposed to permanent outer casing placed into the confining unit. Note that when using the temporary casing practice, it is critical that grout be mixed and placed properly as specified elsewhere in this section.

Because the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, particular care should be taken that the well casing is placed in the center of the drill stem while placing the filter pack. Centralizers may be required to facilitate this in the case of deep wells with PVC casing.

3.3.4 Rotary Methods

These methods consist of a drill pipe or drill stem coupled to a drilling bit that rotates and cuts through the soils. The cuttings produced from the rotation of the drilling bit are transported to the surface by drilling fluids which generally consist of water, drilling mud, or air. The water, drilling mud, or air are forced down through the drill pipe, and out through the bottom of the drilling bit. The cuttings are then lifted to the surface between the borehole wall and the drill

pipe, (or within a concentric drill stem in reverse rotary). The drilling fluids not only force the cuttings to the surface but also keeps the drilling bit cool. When considering this method, it is important to evaluate the potential for contamination when fluids and/or air are introduced into the borehole. If the rotary method is selected as one of the drilling methods, water rotary is the preferred method, followed by air rotary and mud rotary.

Because of the introduction of the various circulating fluids, the use of rotary methods requires that the potential for contamination by these fluids be evaluated. Water and mud rotary methods present the possibility of trace contamination of halogenated compounds when municipal water supplies are used as a potable water source. Air rotary drilling can introduce contamination through the use of lubricants or entrained material in the air stream. In any of the rotary (or sonic) methods, care must be exercised in the selection and use of compounds to prevent galling of drill stem threads.

Water Rotary

When using water rotary, potable water (that has been analyzed for constituents of concern) should be used. If potable water (or a higher quality water) is not available on-site, then potable water will have to be transported to the site or an alternative drilling method will have to be selected. Water rotary is the preferred rotary method because potable water is the only fluid introduced into the borehole during drilling. Water does not clog the formation materials reducing well development time; however this potable water will flow out into the surrounding formation materials (if permeable) and mix with the natural formation water. This mixing of the drilling water and the natural formation water should be evaluated when determining the drilling method. The well development program must be designed to recover the drilling water during the well development process.

Air Rotary

Air rotary drilling uses air as a drilling fluid to entrain cuttings and carry them to the surface. High air velocities, and consequently large air volumes and compressor horsepower are required. Down-the-hole (DTH) percussion hammers driven by the air stream can be used with this method to rapidly penetrate bedrock materials. Where a casing through unconsolidated material is required to prevent borehole collapse, it can be driven in conjunction with advancement of the drill stem.

When using air rotary drilling in any zone of potential contamination, dual-tube reverse circulation with a cyclone velocity dissipater for cuttings containment and separation is the preferred method. Allowing cuttings to blow uncontrolled from the borehole (as with the conventional air rotary method) is not acceptable.

When using air rotary, the issue of contaminants being introduced into the borehole by the air stream must be addressed. Screw compressor systems should have a coalescing filter system in good working order to capture excess entrained compressor oils. The lubricant to be used with DTH hammers as well as thread lubricants to be used on drill stem should be evaluated for their

potential impact on analytical samples.

Mud Rotary

Mud rotary is the least preferred rotary method because contamination can be introduced into the borehole from the constituents in the drilling mud, cross contamination can occur along the borehole column, and it is very difficult to remove the drilling mud from the borehole after drilling and during well development. The drilling mud can also carry contaminates from a contaminated zone to an uncontaminated zone thereby cross-contaminating the borehole. If mud rotary is selected, only potable water and pure (no additives) bentonite drilling muds should be used. All materials used should have adequate documentation as to manufacturer's recommendations and product constituents. QA/QC samples of drilling muds and potable water should be collected at a point of discharge from the circulation system to assure that pumps and piping systems are not contributing cross-contamination from previous use.

3.3.5 Other Methods

Other methods such as the cable-tool method, jetting method, and boring (bucket auger) method are available. If these and/or other methods are selected for monitoring well installations, they should be approved by a senior field geologist before field work is initiated.

3.4 Borehole Construction

The details of the methodology and construction specifications should be specified in project planning documents.

3.4.1 Annular Space

The borehole or hollow stem auger should be of sufficient diameter so that well construction can proceed without major difficulties. For open boreholes, the annular space should be approximately 2-inches to allow the uniform deposition of well materials around the screen and riser, and to allow the passage of tremie pipes and well materials without unduly disturbing the borehole wall. For example, a 2-inch nominal diameter (nom.) casing would require a 6-inch inside diameter (ID) borehole.

In hollow stem augers and sonic method drill casing, the ID should be of sufficient size to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the auger or casing. In general, 4-1/4-inch ID should be the minimum size used for placement of 2-inch nom. casing and 8-1/4-inch ID for 4-inch nom. casing. Larger augers should be used where installation difficulties associated with downhole geologic conditions or where greater depths are anticipated (e.g., larger augers might be required to place a bentonite pellet seal through a long water column).

3.4.2 Borehole Overdrilling

Sometimes it is necessary to overdrill the borehole so that any soils that have not been removed or that have fallen into the borehole during augering or drill stem retrieval, will fall to the bottom of the borehole below the depth where the filter pack and well screen are to be placed.

Normally, 3 to 5 feet is sufficient for overdrilling. The borehole can also be overdrilled to allow for an extra space or a sump area below the well screen. This "sump" area provides a space to attach a section of well casing to the bottom of the well screen. The extra space or sump below the well screen serves as a catch basin or storage area for sediment that flows into the well and drops out of suspension. These sumps are added to the well screens when the wells are screened in aquifers that are naturally turbid and will not yield clear formation water (free of visible sediment) even after extensive development. The sediment can then be periodically pumped out of the sump preventing the well screen from clogging or silting up. If the borehole is overdrilled deeper than desired, it can be backfilled to the designed depth with bentonite pellets, chips, or the filter sand that is to be used for the filter pack.

3.4.3 Filter Pack Placement

When placing the filter pack into the borehole, a minimum of 6-inches of the filter pack material should be placed under the bottom of the well screen to provide a firm footing and an unrestricted flow under the screened area. The filter pack should extend a minimum of 2-feet above the top of the well screen to allow for settling and to isolate the screened interval from the grouting material. In open boreholes, the filter pack should be placed by the tremie or positive displacement method. Placing the filter pack by pouring the sand into an open drill stem is acceptable with the use of hollow stem augers, and other methods where the borehole is temporarily cased down to the filter pack. A tamper can be used to ensure that the material is being placed properly and to rapidly break up any pellet bridging that occurs.

3.4.4 Filter Pack Seal-Bentonite Pellet Seal (Plug)

Bentonite pellets consist of ground, dried bentonite compacted into pellets available in several sizes. Bentonite pellets are compressed to a bulk density of 70-80 lbs/cu.ft. and hydrate to a 30% minimum solids material.

Where neat cement grouts are to be used, the placement of a bentonite pellet seal above the filter pack is mandatory to prevent the possibility of grout infiltration into the screened interval prior to setting. Bentonite chips or other sealing products should not be substituted in this application. Where bentonite grouts are to be used, the placement of a bentonite pellet seal is optional, but desirable.

Because the pellets begin hydrating rapidly, they are very difficult to place by the tremie method. They may be placed by pouring slowly into either open boreholes or hollow stem augers. A tamper should be used to ensure that the material is being placed properly and to rapidly break up any pellet bridging that occurs.

Pellet seals should be designed for a two-foot thickness of dry pellets above the filter pack. Hydration may extend the height of the seal. Where neat cement grouts are to be used the pellets should be hydrated for eight hours, or the manufacturer’s recommended hydration time, whichever is greater. Where the water table is temporarily below the pellet seal, potable (or higher quality) water should be added repeatedly to hydrate the pellets prior to grouting.

3.4.5 Grouting the Annular Space

Where grouting of the annular space is required in the project planning documents. The annular space between the casing and the borehole wall should be filled with either a 30% solids bentonite grout, a neat cement grout or a cement/bentonite grout. Each type of grout selected should be evaluated as to its intended use and integrity.

Bentonite grout shall be a 30% solids pure bentonite grout with a minimum density of 10 lb/gal. Drilling muds are not acceptable for grouting. The grout should be placed into the borehole, by the tremie method, from the top of the bentonite seal to within 2-feet of the ground surface or below the frost line, whichever is the greater depth. The bentonite pellet seal or filter pack should not be disturbed during grout placement, either by the use of a side discharge port on the tremie tube, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal or filter pack. The grout should be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. The preferred method of achieving proper solids content is by measurement of ingredients per the manufacturer's specifications during mixing. Bentonite grouts should have a minimum density of 10 lbs/gal to ensure proper gelling and low permeability. The density of the first batch of grout should be measured while mixing to verify proper measurement of ingredients. In addition, the grouting operation should not cease until the bentonite grout flowing out of the borehole has a minimum density of 10 lbs/gal. A mud balance should be used to measure the specified grout density of the bentonite grout. Estimating the grout density is not acceptable.

Neat cement grouts are generally dictated where a high level of dissolved solids or a particular dissolved constituent would prevent proper gelling of a bentonite grout. Neat cement grouts are typically mixed using 6.5 to 7 gallons of water per 94-lb bag of Type 1 Portland cement. The addition of bentonite (5 to 10 percent) to the cement grout is generally used to delay the setting time and may not be needed in all applications. The specific mixtures and other types of cement and/or grout proposed should be evaluated on a case by case basis by a senior field geologist.

3.4.6 Surface Completion

Two types of surface completions are typical to monitoring well installations: aboveground completion and flush-mounted completion.

An outer protective casing should be installed into the borehole after the annular grout has cured for at least 24 hours. A protective casing is installed around the well riser pipe. The protective casing shall be positioned and installed in a plumb position. Concrete (surface seal) will be placed above and around the base of the protective casing up to and becoming part of the surface concrete pad. The seal shall not extend below the base of the protective casing to allow the draining of any trapped water from installation and sampling of the well. The protective casing should be anchored below the frost depth by the surface seal. The protective casing should extend to a height so that the cap of the inner well casing is exposed when the protective casing is opened.

Regardless of the type of surface completion, a concrete surface pad should be installed around each well at the same time as the outer protective casing is being installed. The surface pad

should be formed around the well casing. Concrete should be placed into the pad forms and into the borehole (on top of the grout) in one operation making a contiguous unit. The size of the surface pad is often specified in project planning documents and is generally dependent on the well casing size. If the well casing is 2 inches in diameter, the pad is typically 3 feet x 3 feet x 4 inches. If the well casing is 4 inches in diameter, the pad is typically 4 feet x 4 feet x 6 inches. Round concrete surface pads are also acceptable. The finished pad should be slightly sloped so that drainage will flow away from the protective casing and off of the pad. A minimum of one inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.

Above Ground Completion

When above ground completion is specified in the project planning documents. The well casing, when installed and grouted, should extend above the ground surface a minimum of 2.5 feet. A vent hole should be drilled into the top of the well casing cap to permit pressure equalization, if applicable. The outer protective casing should be of steel construction with cap that can be locked. Generally, outer protective casings used over 2-inch well casings are 4 inches square by 5 feet long. Similarly, protective casings used over 4-inch well casings are 6 inches square and 5 feet long. Round protective casings are also acceptable. All protective casings should have sufficient clearance around the inner well casings, so that the outer protective casings will not come into contact with the inner well casings after installation. The protective casings should have a minimum of two weep holes for drainage. These weep holes should be a minimum 1/4-inch in diameter and drilled into the protective casings just above the top of the concrete surface pads to prevent water from standing inside of the protective casings. Protective casings made of aluminum or other soft metals are normally not acceptable because they are not strong enough to resist tampering. Aluminum protective casing may be used in very corrosive environments such as coastal areas.

If the monitoring wells are located in a high traffic area, a minimum of three bumper guards consisting of steel pipes 3 to 4 inches in diameter and a minimum 5-foot length should be installed. These bumper guards should be installed to a minimum depth of 2 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete should also be placed into the steel pipe to provide additional strength. Substantial steel rails and/or other steel materials can be used in place of steel pipe. Welding bars between the bumper posts can provide additional strength and protection in high traffic areas, but the protective bumpers should not be connected to the protective casing.

After the wells have been installed, the outer protective casing and bumper guards should be painted with a highly visible enamel paint. The wells should be permanently marked with the well number, date installed, site name, elevation, etc., either on the cover or an appropriate place that will not be easily damaged and/or vandalized.

Flush-Mounted Completion

If the monitoring wells are installed in a high traffic area such as a parking lot, in a residential yard, or along the side of a road it may be desirable to finish the wells to the ground surface and install water-tight flush mounted traffic and/or man-hole covers. Flush mounted traffic and man-

hole covers are designed to extend from the ground surface down into the concrete plug around the well casing. Although flush mounted covers may vary in design, they should have seals that make the unit water-tight when closed and secured. The flush mounted covers should be installed as far above grade as practical to minimize standing water and promote runoff. Permanent identification markings should be placed on the covers or in the concrete plug around the cover. Expansive sealing plugs may be used in the well riser to prevent infiltration of any water that might enter the flush cover.

The well casing must be cut off below grade, leaving enough space for the placement of an end plug or casing cap at each well. A protective structure, such as a utility or Christie valve box assembly, will be installed around the well riser pipe. The surface seal will be placed above and around the base of the valve box up to and becoming part of the concrete surface pad. The seal shall not extend below the base of the valve box assembly to allow the draining of any trapped water from installation or sampling. The protective structure shall be centered in a 3-foot-square concrete pad sloped away from the structure. For flush-mounted completions located in high traffic areas, completion will follow the procedures outlined above except that an appropriate traffic-rated cement or steel vault will be used and cemented flush with the traffic surface. For these flush-mounted completions, care should be used to ensure that the bond between the protective structure and the cement surface seal, and the protective structure and the removable cover are watertight. Use of expanding cement and flexible gaskets are suggested.

3.5 Construction Techniques

3.5.1 Well Installation

The borehole should be bored, drilled, or augered as close to vertical as possible, and checked with a plumb bob or level if specified in the project planning documents. Deviation from plumb should be within 1 degree per 50 feet of depth. Slanted boreholes will not be acceptable unless specified in the design. The depth and volume of the borehole, including the overdrilling if applicable, should have been calculated and the appropriate materials procured prior to drilling to suspend the string of well screen and casings in the borehole by means of the wireline on the drill rig. The string of well screen and casings can be placed into the borehole and plumbed in one easy operation. This wireline method is especially useful if the borehole is deep and a long string of well screen and casings have to be set and plumbed. No lubricating oils or grease should be used on casing threads. Teflon® tape can be used to wrap the threads to insure a tight fit and minimize leakage. No glue of any type should be used to secure casing joints. Teflon® O-rings can also be used to insure a tight fit and minimize leakage; however, O-rings made of other materials are not acceptable if the well is going to be sampled for organic compound analyses. Before the well screen and casings are placed on the bottom of the borehole, at least 6 inches of filter material should be placed at the bottom of the borehole to serve as a firm footing. The string of well screen and casings should then be placed into the borehole and plumbed. Centralizers can be used to plumb a well, but centralizers should be placed so that the placement of the filter pack, bentonite pellet seal, and annular grout will not be hindered. Centralizers placed in the wrong locations can cause bridging during material placement. Monitoring wells less than 50 feet deep generally do not need centralizers. If centralizers are used they should be placed below the well screen and above the bentonite pellet seal. The specific placement

intervals should be decided based on site conditions. When installing the well screen and casings through hollow-stem augers, the augers should be slowly extracted as the filter pack, bentonite seal, and grout are tremied and/or poured into place. The gradual extraction of the augers will allow the materials being placed in the augers, to flow out of the bottom of the augers into the borehole. If the augers are not gradually extracted, the materials (sand, pellets, etc.) will accumulate at the bottom of the augers causing potential bridging problems.

After the string of well screen and casing is plumb, the filter material should then be placed around the well screen (by the tremie method in open boreholes) up to the designated depth. After the filter pack has been installed, the bentonite pellet seal (if used) should be placed directly on top of the filter pack to an unhydrated thickness of two feet. When installing the seal for use with neat cement grouts, the bentonite pellet seal should be allowed to hydrate a minimum of eight hours or the manufacturer's recommended hydration time, whichever is longer. After the pellet seal has hydrated for the specified time, the grout should then be pumped by the tremie method into the annular space around the casings up to within 2 feet of the ground surface or below the frostline, whichever is the greater depth.

3.5.2 Double Cased Wells

Double cased wells should be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross contamination, and/or when flowing sands make it impossible to install a monitoring well using conventional methods. A pilot borehole should be bored through the overburden and/or the contaminated zone into the clay confining layer or bedrock. An outer casing (sometimes called surface or pilot casings) should then be placed into the borehole and sealed with grout. The borehole and outer casing should extend into tight clay a minimum of two feet and into competent bedrock a minimum of 1 foot. The total depths into the clay or bedrock will vary, depending on the plasticity of the clay and the extent of weathering and/or fracturing of the bedrock. The final depths should be approved by a senior field geologist. The size of the outer casing should be of sufficient ID to contain the inner casing, and the 2-inch minimum annular space. In addition, the borehole should be of sufficient size to contain the outer casing and the 2-inch minimum outer annular space, if applicable.

The outer casing should be grouted by the tremie method from the bottom to within 2 feet of the ground surface. The grout should be pumped into the annular space between the outer casing and the borehole wall. This can be accomplished by either placing the tremie tube in the annular space and pumping the grout from the bottom of the borehole to the surface or placing a grout shoe or plug inside the casing at the bottom of the borehole and pumping the grout through the bottom grout plug and up the annular space on the outside of the casing. If the outer casing is set into very tight clay, both of the above methods might have to be used, because the clay usually forms a tight seal in the bottom and around the outside of the casing preventing grout from flowing freely during grout injection. On the other hand, outer casing set into bedrock normally will have space enough to allow grout to flow freely during injection. A minimum of 24 hours should be allowed for the grout plug (seal) to cure before attempting to drill through it. The grout mixture used to seal the outer annular space should be either a neat cement,

cement/bentonite, cement/sand, or a 30% solids bentonite grout. However, the seal or plug at the bottom of the borehole and outer casing should consist of a Type I portland cement/bentonite or cement/sand mixture. The use of a pure bentonite grout for a bottom plug or seal is not acceptable, because the bentonite grout cures to a gel-like material and is not rigid enough to withstand the stresses of drilling. When drilling through the seal, care should be taken to avoid cracking, shattering, and/or washing out the seal, which will be discussed in the next section. If caving conditions exist so that the outer casing cannot be sufficiently sealed by grouting, the outer casing should be driven into place and a grout seal placed in the bottom of the casing. Removal of outer casings, which are sometimes called temporary surface casings, after the well screens and casings have been installed and grouted is not acceptable. Trying to remove outer surface casings after the inner casings have been grouted could jeopardize the structural integrity of the well.

Bedrock Wells

The installation of monitoring wells into bedrock can be accomplished in two ways:

The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock. An outer casing is then installed into the borehole by setting it into the bedrock and grouting it into place as described in the previous section. After the grout has set, the borehole can then be advanced through the grout seal into the bedrock. The preferred method of advancing the borehole into the bedrock is rock coring. Rock coring makes a smooth, round hole through the seal and into the bedrock without cracking and/or shattering the seal. Roller cone bits are used in soft bedrock, but extreme caution should be taken when using a roller cone bit to advance through the grout seal in the bottom of the borehole because excessive water and downhole pressure can cause cracking, eroding (washing), and/or shattering of the seal. Low volume air hammers may be used to advance the borehole, but they have a tendency to shatter the seal because of the hammering action. If the structural integrity of the grout seal is in question, a pressure test can be utilized to check for leaks. A visual test can also be made by examining the cement/concrete core that is collected when the seal is cored with a diamond coring bit. If the seal leaks (detected by pressure testing) and/ or the core is cracked or shattered, or if no core is recovered because of washing, excessive down pressure, etc., the seal is not acceptable. The concern over the structural integrity of the grout seal applies to all double cased wells. Any proposed method of double casing and/or seal testing should be evaluated on its own merits and will have to be approved by a senior field geologist before and during drilling activities, if applicable. When the drilling is complete, the finished well will consist of an open borehole from the ground surface to the bottom of the well. There is no inner casing, and the outer surface casing, installed down into bedrock, extends above the ground surface, and also serves as the outer protective casing. If the protective casing becomes cracked or is sheared off at the ground surface, the well is open to direct contamination from the ground surface and will have to be repaired immediately or abandoned. Another limitation to the open rock well is that the entire bedrock interval serves as the monitoring zone. In this situation, it is very difficult or even impossible to monitor a specific zone, because the constituents of concern being monitored could be diluted to the extent of being nondetectable. The installation of open bedrock wells is generally not acceptable in CERCLA and RCRA programs, because of the uncontrolled

monitoring intervals. However, some site conditions might exist, especially in cavernous limestone areas (Karst topography) or in areas of highly fractured bedrock, where the installation of the filter pack and its structural integrity are questionable. Under these conditions the design of an open bedrock well may be warranted.

The second method of installing a monitoring well into bedrock is to install the outer surface casing and drill the borehole (by an approved method) into bedrock, and then install an inner casing and well screen with the filter pack, bentonite seal, and annular grout. The well is completed with a surface protective casing and concrete pad. This well installation method gives the flexibility of isolating the monitoring zone(s) and minimizing inter-aquifer flow. In addition, it gives structural integrity to the well, especially in unstable areas (e.g., steeply dipping shales, etc.) where the bedrock has a tendency to shift or move when disturbed. Omitting the filter pack around the well screen is a general practice in some open rock borehole installations, especially in drinking water and irrigation wells. However, without the filter pack to protect the screened interval, sediment particles from the well installation and/or from the monitoring zone could clog the well screen and/or fill the screened portion of the well rendering it inoperable. Also, the filter pack serves as a barrier between the bentonite seal and the screened interval. Rubber inflatable packers have been used to place the bentonite seal when the filter pack is omitted, but the packers have to remain in the well permanently and, over a period of time, will decompose and possibly contribute contaminants to the monitoring zone.

3.6 Well Construction Materials

3.6.1 Introduction

Well construction materials are chosen based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site(s). The different types of available materials are discussed in the following sections.

3.6.2 Well Screen and Casing Materials

Well screen and casing materials are generally made of polyvinyl chloride or stainless steel. Project planning documents should specify the materials and diameter of the well screen and casing materials, as well as the screen length.

The minimum nominal casing size for most permanent monitoring wells typically will be 2-inch. Where a complete program of installation, monitoring, and abandonment is being designed, smaller wells may be installed if suitable purging and sampling equipment for the smaller diameter wells can be specified and obtained. The length of well screens in permanent monitoring wells should be long enough to effectively monitor the interval or zone of interest. However, well screens designed for long term monitoring purposes should normally not be less than 5 feet in length. Well screens less than 5 feet long are typically acceptable only in temporary monitoring wells where ground water samples are collected for screening purposes.

3.6.3 Filter Pack Materials

The filter pack materials should consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain-size distribution or particle sizes of the

filter pack materials should be selected based upon a sieve analysis conducted on the soil samples collected from the aquifer materials and/or the formation(s) to be monitored. Filter pack materials should not be accepted unless proper documentation can be furnished as to the composition, grain-size distribution, cleaning procedure, and chemical analysis. If a data search reveals that there are enough existing data to adequately design the well screen and filter pack, then it may not be necessary to conduct a sieve analysis on the formation materials to be monitored. However, all data and design proposals will be evaluated and approved by a senior staff geologist before field activities begin.

3.6.4 Filter Pack and Well Screen Design

The majority of monitoring wells are installed in shallow ground water aquifers that consist of silts, clays, and sands in various combinations. Project planning documents will indicate if sieve analysis conducted on soil sampled collected from the aquifer or formation(s) is needed to design the filter pack and well screen.

In formations consisting primarily of fines (silts and clays), the procedures for water well screen design may result in requirements for filter packs and screen slot sizes that are not available. In those circumstances the selection of 0.010-inch screen slots with a 20-40 sand filter pack, or 0.005-inch screen slots with 100 sand filter pack for very fine formations, is typically an acceptable practice. Table 1 provides size specifications for the selection of sand packs for fine formation materials. ASTM standard D5092, Design and Installation of Ground Water Monitoring Wells in Aquifers, may be consulted for further guidance on specifications for sand appropriate for these applications.

Table 1
Sand Pack Specifications

Screen Opening (in)	Sand Pack Mesh Name	1% Passing Size (d-1) (in)	10% Passing Size (d-10) (in)	30% Passing Size (d-30) (in)	Derived 60% Passing Size (d-60) (in)	Range for Uniformity Coefficient
0.005"-0.006"	100	3.5 - 4.7	5.5 - 6.7	6.7 - 8.3	8.5 - 13.4	1.3 - 2.0
0.010"	20-40	9.8 - 13.8	15.7 - 19.7	19.7 -23.6	20 - 31.5	1.1 - 1.6

The following procedure should be used in coarser grained formations.

The data from the sieve analysis are plotted on a grain-size distribution graph, and a grain-size distribution curve is generated. From this grain-size distribution curve, the uniformity coefficient (Cu) of the aquifer material is determined. The Cu is the ratio of the 60 percent finer material (d60) to the 10 percent finer material (d10):

$$Cu = (d60/d10)$$

The Cu ratio is a way of grading or rating the uniformity of grain size. For example, a Cu of unity means that the individual grain sizes of the material are nearly all the same, while a Cu with a large number means a large range of sizes. As a general rule, a Cu of 2.5 or less should be used in designing the filter pack and well screen.

Before designing the filter pack and well screen, the following factors should be considered:

- Select the well screen slot openings that will retain 90 percent of the filter pack material.
- The filter pack material should be of the size that minimizes head losses through the pack and also prevents excessive sediment (sand, silt, clay) movement into the well.
- A filter material of varying grain sizes is not acceptable because the smaller particles fill the spaces between the larger particles thereby reducing the void spaces and increasing resistance to flow. Therefore, filter material of the same grain size and well-rounded is preferred.
- The filter pack design is based on the gradation of the finest aquifer materials being analyzed. Steps to design a filter pack in aquifers:
    - Construct a grain-size distribution curve, on a grain-size distribution graph, from the sieve analysis of the aquifer materials. The filter pack design (as stated above) is based on the gradation of the finest aquifer materials.
    - Multiply the d30 size from the grain-size distribution graph by a factor of four to nine (Pack- Aquifer ratio[P-A]). A factor of four is used if the formation is fine-grained and uniform (Cu is less than 3), six if it is coarse-grained and non-uniform, and up to nine if it is highly non-uniform and contains silt. Head losses through filter packs increase as the P-A ratios decrease. In order to design a fairly stable filter pack with a minimum head loss, the d30 size should be multiplied by a factor of four.
    - Plot the point from Step 2 on the d30 abscissa of a grain-size distribution graph and draw a smooth curve with a uniformity coefficient of approximately 2.5.
    - A curve for the permissible limits of the filter pack is drawn plus or minus 8 percent of the desired curve with the Cu of 2.5.
    - Select the slot openings for the well screen that will retain 90 per cent or more of the filter pack material.

The specific steps and procedures for sieve analysis and filter pack design can be found in soil mechanics, ground water, and water well design books. The staff geologists and/or engineers should be responsible for the correct design of the monitoring wells and should be able to

perform the design procedures.

3.7 Safety Procedures for Drilling Activities

A site health and safety plan should be developed and approved by Project Management prior to any drilling activities, and should be followed during all drilling activities. The designated safety person should be responsible for the safety of the drilling team performing the drilling activities. All subcontractor personnel conducting drilling activities should be qualified in proper drilling and safety procedures. Before any drilling activity location of all underground utilities or structures should be conducted as specified in the site health and safety plan. If specified in the site health and safety plan, before operating the drill rig, a pilot hole should be dug (with hand equipment) to a depth of two to three feet to check for undetected utilities or buried objects. Proceed with caution until a safe depth is reached where utilities normally would not be buried. Safety precautions should be reviewed with all field staff prior to activities.

3.8 Well Development

A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed. This will allow sufficient time for the well materials to cure before development procedures are initiated. The main purpose of developing new monitoring wells is to remove the residual materials remaining in the wells after installation has been completed, and to try to re- establish the natural hydraulic flow conditions of the formations which may have been disturbed by well construction, around the immediate vicinity of each well. A new monitoring well should be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In most cases the above requirements can be satisfied; however, in some cases the pH, temperature, and specific conductivity may stabilize but the water remains turbid. In this case the well may still contain well construction materials, such as drilling mud in the form of a mud cake and/or formation soils, that have not been washed out of the borehole. Excessive or thick drilling muds typically cannot be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete the well development. If the well is pumped to dryness or near dryness, the water table should be allowed to sufficiently recover (to the static water level) before the next development period is initiated. Caution should be taken when using high rate pumps and/or large volume air compressors during well development because excessive high rate pumping and high air pressures can damage or destroy the well screen and filter pack. The onsite geologist should make the decision as to the development completion of each well. All field decisions should be documented in the field log book.

The following development procedures, listed in increasing order of the energy applied to the formation materials, are generally used to develop monitoring wells:

1. Bailing
2. Pumping/Overpumping
3. Surging

4. Backwashing
5. Jetting
6. Compressed air (with appropriate filtering): airlift pumping and air surging

These developmental procedures can be used, individually or in combination, in order to achieve the most effective well development. In most cases, overpumping and surging will adequately develop the well without imparting undue forces on the formation or well materials. Except when compressed air is being used for well development, sampling can be initiated as soon as the ground water has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. However, the site-specific project planning documents must be reviewed to determine if project conditions require a specified period after development prior to sampling. Because site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new monitoring well. Wells developed with stressful measures may require as long as a 7-day interval before sampling. In particular, air surge developed wells require 48 hours or longer after development so that the formation can dispel the compressed air and restabilize to pre-well construction conditions. Because of the danger of introducing contaminants with the airstream, the possibility of entraining air in the aquifer, and the violent forces imparted to the formation, air surging is the least desired method of development. The selected development method(s) should be approved by a senior field geologist before any well installation activities are initiated.

3.9 Well Abandonment

When a decision is made to abandon a monitoring well, the borehole should be sealed in such a manner that the well cannot act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers. To properly abandon a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete. In order to comply with state well abandonment requirements, the appropriate state agency should be notified (if applicable) of monitoring well abandonment. However, some state requirements are not explicit, so a technically sound well abandonment method should be designed based on the site geology, well casing materials, and general condition of the well(s).

3.9.1 Abandonment Procedures

As previously stated the preferred method should be to completely remove the well casing and screen from the borehole. This may be accomplished by augering with a hollow-stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig. The clean borehole can then be backfilled with the appropriate grout material. The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method). The top 2 feet of the borehole should be poured with concrete to insure a secure surface seal (plug). If the area has heavy traffic use, and/or the well locations need to be permanently marked, then a protective surface pad(s) and/or steel bumper guards should be installed. The concrete surface plug can also be recessed below ground surface if the potential for construction activities exists. This abandonment method can

be accomplished on small diameter (1-inch to 4-inch) wells without too much difficulty. With wells having 6-inch or larger diameters, the use of hollow-stem augers for casing removal is very difficult or almost impossible. Instead of trying to ream the borehole with a hollow-stem auger, it is more practical to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole. Wells with little or no grouted annular space and/or sound well casings can be removed in this manner. However, old wells with badly corroded casings and/or thickly grouted annular space have a tendency to twist and/or break-off in the borehole. When this occurs, the well will have to be grouted with the remaining casing left in the borehole. The preferred method in this case should be to pressure grout the borehole by placing the tremie tube to the bottom of the well casing, which will be the well screen or the bottom sump area below the well screen. The pressurized grout will be forced out through the well screen into the filter material and up the inside of the well casing sealing holes and breaks that are present. The tremie tube should be retracted slowly as the grout fills the casing. The well casing should be cut off even with the ground surface and filled with concrete to a depth of 2 feet below the surface. If the casing has been broken off below the surface, the grout should be tremied to within 2 feet of the surface and then finished to the ground surface with concrete. The surface pad or specified surface protection shall then be installed.

A PVC well casing may be more difficult to remove from the borehole than a metal casing, because of its brittleness. If the PVC well casing breaks during removal, the borehole should be cleaned out by using a drag bit or roller cone bit with the wet rotary method to grind the casing into small cuttings that will be flushed out of the borehole by water or drilling mud. Another method is to use a solid-stem auger with a carbide tooth bit to grind the PVC casing into small cuttings that will be brought to the surface on the rotating flights. After the casing materials have been removed from the borehole, the borehole should be cleaned out and pressure grouted with the approved grouting materials. As previously stated, the borehole should be finished with a concrete surface plug and adequate surface protection, unless directed otherwise.

3.10 Temporary Monitoring Well Installation

3.10.1 Introduction

Five types of temporary monitoring well installation techniques have been demonstrated as acceptable. The type selected for a particular site is dependent upon site conditions. Optimally, the project leader and site geologist should be prepared to test temporary well installations on site and select the best solution. Temporary wells are cost effective, may be installed quickly, and provide a synoptic picture of ground water quality.

Temporary monitoring well locations are not permanently marked, nor are their elevations normally determined. Sand pack materials may or may not be used, but typically there is no bentonite seal, grout, surface completion, or extensive development (as it normally applies to permanent monitoring wells). Temporary wells are generally installed, purged, sampled, removed, and backfilled in a matter of hours.

Because of the nature of construction, turbidity levels may initially be high. However, these

levels may be reduced by low flow purging and sampling techniques.

Temporary wells may be left overnight, for sampling the following day, but the well must be secured. If the well is not sampled immediately after construction, the well should be purged prior to sampling.

3.10.2 Data Limitation

Temporary wells described in this section are best used for delineation of contaminant plumes, at a point in time, and for specific site screening purposes. They are not intended to replace permanent monitoring wells. Typically the best use for temporary wells is in conjunction with a mobile laboratory, where quick analytical results can be used to delineate contaminant plumes.

3.10.3 Temporary Well Materials

Materials used in construction of temporary monitoring wells are the same standard materials used in the construction of permanent monitoring wells. Sand used for the filter pack (if any) should be as specified in Section 3.6.3. The well screen and casing are usually stainless steel or PVC. Commercially available temporary well materials, pre-packed riser, screen and filter pack assemblies are commonly used; however, these pre-assembled materials cannot be cleaned. Appropriate QA/QC must be performed to assure there will be no introduction of contamination.

3.10.4 Temporary Monitoring Well Borehole Construction

Borehole construction for temporary wells is as specified in Section 3.4, using a drill rig. Alternatively, boreholes may be constructed using hand augers or portable powered augers (generally limited to depths of ten feet or less). If a drill rig is used to advance the borehole, the augers must be pulled back the length of the well screen (or removed completely) prior to sampling. When hand augers are used, the borehole is advanced to the desired depth (or to the point where borehole collapse occurs). In situations where borehole collapse occurs, the auger bucket is typically left in the hole at the point of collapse while the temporary well is assembled. When the well is completely assembled, a final auger bucket of material is quickly removed and the well is immediately inserted into the borehole, pushing, as needed, to achieve maximum penetration into the saturated materials.

3.10.5 Temporary Monitoring Well Types

Five types of monitoring wells which have been shown to be acceptable are presented in the order of increasing difficulty to install and increasing cost:

<u>No Filter Pack</u>

This is the most common temporary well and is very effective in many situations. After the borehole is completed, the casing and screen are simply inserted. This is the most inexpensive and fastest well to install. This type well is extremely sensitive to turbidity fluctuations, because there is no filter pack. Care should be taken to not disturb the casing during purging and sampling.

<u>Inner Filter Pack</u>

This type differs from the "No Pack" only in that a filter pack is placed inside the screen to a level approximately 6 inches above the well screen. This ensures that all water within the casing has passed through the filter medium. For this type well to function properly, the static water level must be 6-12 inches above the filter pack.

Traditional Filter Pack

For this type, the screen and casing are inserted into the borehole, and the sand is poured into the annular space surrounding the screen and casing. Occasionally, it may be difficult to effectively place a filter pack around a shallow open borehole because of collapse. This method requires more sand than the "inner filter pack" well, increasing material costs. As the filter pack is placed, it mixes with the muddy water in the borehole, which may increase the amount of time needed to purge the well to an acceptable level of turbidity.

Double Filter Pack

The borehole is advanced to the desired depth. As with the "inner filter pack" the well screen is filled with filter pack material and the well screen and casing inserted until the top of the filter pack is at least 6 inches below the water table. Filter pack material is poured into the annular space around the well screen. This type temporary well construction can be very effective in aquifers where fine silts or clays predominate. This construction technique takes longer to implement and uses more filter pack material than others previously discussed.

Well-in-a-Well

The borehole is advanced to the desired depth. At this point, a 1-inch well screen and sufficient riser is inserted into a 2-inch well screen with sufficient riser and centered. Filter pack material is then placed into the annular space surrounding the 1-inch well screen, to approximately 6 inches above the screen. The well is then inserted into the borehole. This system requires twice as much well screen and casing, with subsequent increase in material cost. The increased amount of well construction materials results in a corresponding increase in decontamination time and costs. If pre-packed wells are used, a higher degree of QA/QC will result in higher overall cost.

3.10.6 Backfilling

It is the generally accepted practice to backfill the borehole from the abandoned temporary well with the soil cuttings. Use of cuttings would not be an acceptable practice if waste materials were encountered or a confining layer was inadvertently breached. Likewise, where the borehole is adjacent to or, downslope of contaminated areas, the loose backfilled material could create a high permeability conduit for the contaminant migration. If for a site-specific reason the borehole cannot be backfilled with the soil cuttings, then the same protocols set forth in Section 3.9 should be applied.

3.11 Temporary Monitoring Well Installation Using DPT Equipment

3.11.1 Introduction

The following text provides details of temporary well installation using specific information for Geoprobe® brand DPT equipment. The general descriptions and approach would be similar for

DPT equipment provided by other manufacturers.

The Geoprobe® Screen Point 15 Groundwater Sampler is a discrete interval ground water sampling device that can be pushed to pre-selected sampling depths in saturated, unconsolidated materials, opened and sampled as a temporary monitoring well. It is a sealed sample device, opened at the desired depth, yielding a representative, uncompromised sample from that depth. Using knock-out plugs, this method also allows for grouting of the push hole during sample tool retrieval after sample collection.

The Screen Point 15 sampler consist of four parts (drive point, screen, sampler sheath and drive head), with an assembled length of 52 inches and a maximum OD of 1.5 inches. When opened, it has an exposed screen length of 41 inches. It is typically pushed using 1.25-inch probe rod.

The following is a step-by-step description of the components and procedures used to install a Screen Point 15 Groundwater Sampler.

3.11.2 Assembly of Screen Point 15 Groundwater Sampler

- Install O-ring on expendable point and firmly seat in the necked end of the sampler sheath.
- Place a grout plug in the lower end of the screen section.
- When using a stainless steel screen, place another O-ring in the groove on the upper end of the screen and slide it into the sampler sheath.
- Place an O-ring on the bottom of the drive head and thread into the top of the sampler sheath.
- The sampler is now assembled and ready to push for sample collection.

3.11.3 Installation of Screen Point 15 Groundwater Sampler

- Attach drive cap to top of sampler and slowly drive it into the ground. Raise the hammer assembly, remove the drive cap and place an O-ring in the top groove of the drive head. Add a probe rod and continue push.
- Continue to add probe rods until the desired sampling depth is reached.
- When the desired sampling depth is reached, re-position the probe derrick and position either the casing puller assembly or the rod grip puller over the top of the top probe rod.
- Thread a screen push adapter on an extension rod and attach sufficient additional extension rods to reach the top of the sampler. Add an extension handle to the top of the string of extension rods and run this into the probe rod, resting the screen push adapter on top of the sampler.
- To expose the screened portion of the sampler, exert downward pressure on the sampler, using the extension rod and push adapter, while pulling the probe rod upward. To expose the entire open portion of the screen, pull the probe rod upward approximately 41 inches.
- At this point, the sampler has been installed as a temporary well and may be sampled using appropriate ground water sampling methodology. Field sampling personnel typically use a peristaltic pump, utilizing low-flow methods, to collect ground water samples from these installations.

3.11.4 Special Considerations for Screen Point 15 Installations Grouting

In many applications, it may be appropriate to grout the abandoned probe hole where a sampler was installed. This is accomplished via pressure grouting through the probe rod during sampler retrieval. To accomplish this, the grout plug is knocked out of the bottom of the screen using a grout plug push adapter and a grout nozzle is fed through the probe rod, extending just below the bottom of the screen. As the probe rod and sampler are pulled, grout is injected in the open hole below the screen at a rate that just fills the open hole created by the pull. Teflon® grout plugs are typically used for this method of abandonment.

Screen Material Selection

Screen selection is also a consideration in sampling with the sampler. Screens are typically available in two materials, stainless steel and PVC. Because of stainless steel's durability, ability to be cleaned and re-used and overall inertness and compatibility with most contaminants, it is the choice of materials for many investigations.

4.0 REFERENCES

National Ground Water Association. Manual of Water Well Construction Practices, NGWA, Westerville, OH.

US-EPA. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells (EPA/600/4-89, March 1991).

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		Prepared by: Robert Gregory	
Subject: **SOIL DESCRIPTION**		Approved by: Stephen Deeter	

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1.0 PURPOSE

In support of environmental characterization projects soil description logs are generated with certain specific information for each completed soil boring. In addition, someone other than the field sampler may be the primary author of the report that will rely on the logs. Therefore, all information is required to be provided in a consistent format.

2.0 SCOPE AND APPLICABILITY

Each soil boring soil sampling, as well as surface grab samples to address project specific requirements, must be described in a manner that provides the data user/review with sufficient information to understand the geo-environmental setting under investigation. Soil samples collected via various drilling operations typically generate soil samples for description by split-barrel (aka split spoon) samplers or undisturbed (aka Shelby) tube samplers. In addition, for "borings" and well installations completed via Direct Push Technology (DPT) methods, a boring log is required in all situations. For DPT borings completed without soil sample collection and description, the boring log will record all pertinent information regarding date, time, personnel and equipment, note the total depth of the boring, and note No Soil Samples Collected.

3.0 REQUIRED PARAMETERS FOR ALL SOIL BORING LOGS

The required information and the order that the required information should be recorded on a boring log. As a qualified professional responsible for the collection and recording of field data, each individual is expected to be completely knowledgeable of all data collection requirements as part of the everyday job description. Sample descriptions guides are available to facilitate consistent sample descriptions, as shown in Attachment 1.

3.1 Depth

All depths should be recorded in increments of feet, with the smallest distinguishable feature described down to the nearest 0.1-foot interval.

3.2 Blow Counts

If Standard Penetration Test (SPT) protocols are used, record counts per 6-in interval. Record Hammer Weight, split barrel sampler (SBS) diameter, and note if manual (cathead) or auto-hammer.

3.3 Unified Soil Classification (USCS) Symbol

The USCS classification of the soil, including soil group name in all CAPITAL LETTERS, should be recorded on the log following the visual manual procedures identified in ASTM D 2488-17. The major soil groups are outlined on the Soil Field Guide provided in Attachment 1.

An example of this would be:

- SW - Well graded GRAVELLY SAND

3.4 Components and Estimated Percentages (Proportions)

Classification of a soil into a USCS soil group inherently estimates the percentages of the primary soil components; however, component proportions should still be estimated on the log. Confirm that all estimated percentages are consistent with the allowable range for the specific USCS Classification. Component percentages should be estimated to the nearest 10%, or 5% where possible. ASTM designated descriptive terms (D 2488-17) can be used to describe secondary components of the soil; however, the terms need to be defined on the log. The Sample Description Guides shown in Attachment 1 provide ASTM designated descriptive terms that should be used on the log. The component proportion description should also include the grain-size and grain angularity for coarse-grained soils (i.e., sands and gravels).

An example of this would be:

- SW - Well graded GRAVELLY SAND – 60% fine to coarse-grained, subrounded to subangular sand, 30% fine-grained gravel (maximum size 1 inch), 10% silt and clay with…

Abbreviations can be used on the boring logs to save time, as long as they are defined somewhere on the log. The above example could be abbreviated to the following to save time while logging (be consistent and define all abbreviations):

- SW - W. graded GRAVELLY SAND – 60% fg to cg, subround to subang sand, 30% fg gravel (< 1 inch), 10% silt and clay with…

3.5 Moisture Content

Next to the USCS classification, moisture content is probably one of the most important parameters to observe and document in the field. At a minimum, moisture contents should be estimated qualitatively using the ASTM designations of dry, moist, and wet (see Attachment 1 - Example Sample Description Guides for definitions). These are the most easily distinguishable moisture conditions of a soil, and the description of moisture content should usually be limited to these designations. The depth to groundwater, if encountered, should also be recorded on the log along with the date and time it was measured.

3.6 Consistency [cohesive soils (silt/clay)] and Density [cohesionless soils (sand)]

Soil investigations commonly are conducted using two-inch split barrel samplers using the SPT. When the SPT method is used, the consistency of cohesive soil and density of cohesionless soils can be determined by adding the blow counts required to advance the split spoon sampler over two consecutive six-inch intervals. This value is referred to as the N value of the soil. For 18-inch length split spoons, the blow counts for the second and third six-inch intervals are added together to get the N value, while the first six-inch interval is ignored. For 24-inch length split spoons, the blow counts for the second and third six-inch intervals are added together to get the N value, while the first and fourth six-inch intervals are ignored. Record the data as follows:

- N / Driven Interval (inches) ex: 8 / 18

The descriptive term for each range of N values representing different consistencies or densities of a soil are provided in the Sample Description Guides (Attachment 1).

When the SPT method is not used to collect soil samples, or as a check of the N value provided by SPT, the manual procedures described in ASTM D 2488-17 can be used to determine the consistency of cohesive soils and density of cohesionless soils. These tests are intended to be conducted on in-place soils, but they also can be used on samples collected from a borehole.

These manual procedures are summarized on the Sample Description Guides shown in Attachment 1.

3.7 Plasticity [cohesive soils (silt/clay) only]

Qualitative observations of the plasticity characteristics of a soil in the field can also provide an indication of the silt and clay content. As this is typically done manually, consistency from sample to sample is important.

The ASTM designations for different levels of plasticity are provided on the Sample Description Guides shown in Attachment 1.

3.8 Color

Color is the most obvious and easily identifiable attribute of a soil. The color of a soil should be identified using a Munsell Soil Color Chart (Attachment 2). You must reference the edition that is being using in the field on the log. You should always keep in mind that color is not typically an important attribute of the soil; therefore, a lot of time should not be wasted trying to determine if the color of the soil is one Munsell color or the other (i.e., is it a 10YR 4/2 or 10YR 4/4?).

3.9 Texture, Fabric, and Bedding and Orientation

Any structures (e.g., fissures, lenses, blocky, slickensided, etc.) and their orientation observed in the field should be documented on the boring log. In addition to these structures, the fabric (e.g., homogeneous, heterogeneous) and bedding (e.g., stratified, laminated, fining upwards, etc.) of the soil should also be documented. Fissures and joints are probably the most important structures to note on boring logs in support of environmental characterization because their presence may control ground water flow rates and directions.

3.10 Depositional Environment

This can be difficult to interpret in the field, and may not be possible, but it is a requirement when the depositional environment can be identified. Note on the logs when objects (e.g., fossils [identify if you can], charred wood fragments, other types of vegetation, etc.) are observed that would be indicative of a depositional environment. Further identification of the depositional environment can be done back in the office during the data assessment phase after completing an adequate literature review, and a review of all boring logs completed in the area. Typically, an environmental investigation is focused on the presence and potential movement of contaminants in the soil rather than a definitive exercise in the naming of geologic units. Described soil characteristics may indicate or suggest that the sampled soils appear to be from the XYZ Formation.

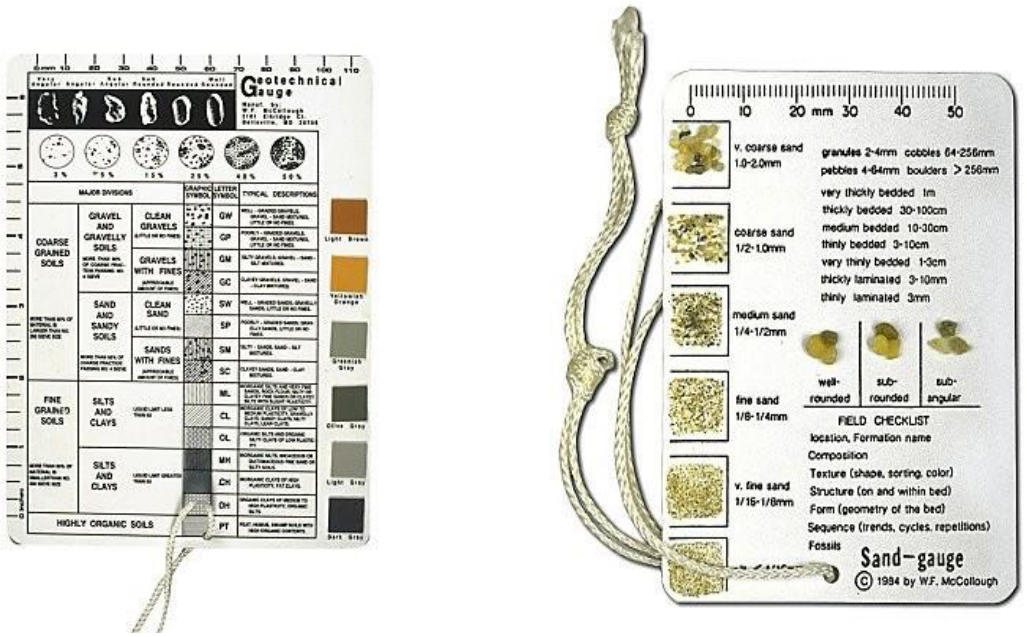
3.11 Mineralogy

If the soil contains easily identifiable and indicative minerals, include this information on the logs. Examples of easily identifiable minerals include micas (e.g., biotite, muscovite, etc.), quartz, calcite, glauconite, and others. Observation of these minerals may aid in indicating what geologic formations were encountered in the soil boring, and correlation of formations between soil boring locations. This can be difficult, and probably should only be noted on the logs when there is adequate time, and strong personal background in mineralogy.

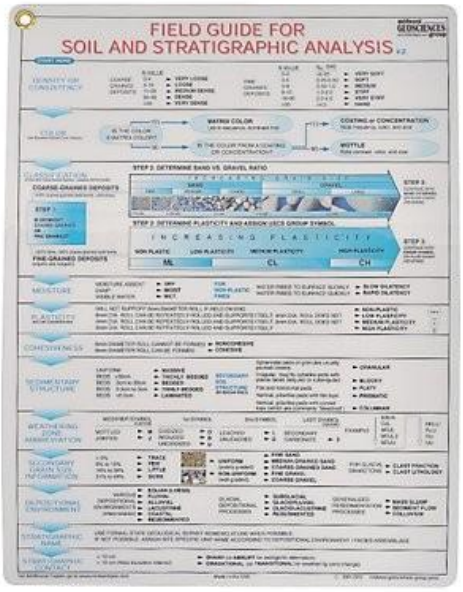
4.0 REFERENCES

ASTM. Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (D2488-17).

ATTACHMENT 1
EXAMPLE SAMPLE DESCRIPTION GUIDES



Source: W.F. McCollough, 1984.



Source: Midwest Geosciences, 2013.

Attachment B

Soil Boring Log

KOMAN Government Solutions, LLC
SOIL BORING LOG

Project:	Boring No.:
Project No.:	Drilling Co.:
Address:	Driller:
Logger:	Drilling Method:
Date:	Drilling Equip:
Total Boring Depth:	Static Water:

Core Section	Recovery (ft)	Interval (ft)	PID (ppm)	GEOLOGIC LOG	REMARKS

Notes:

KOMAN Government Solutions, LLC 293 Boston Post Road, Marlborough, MA

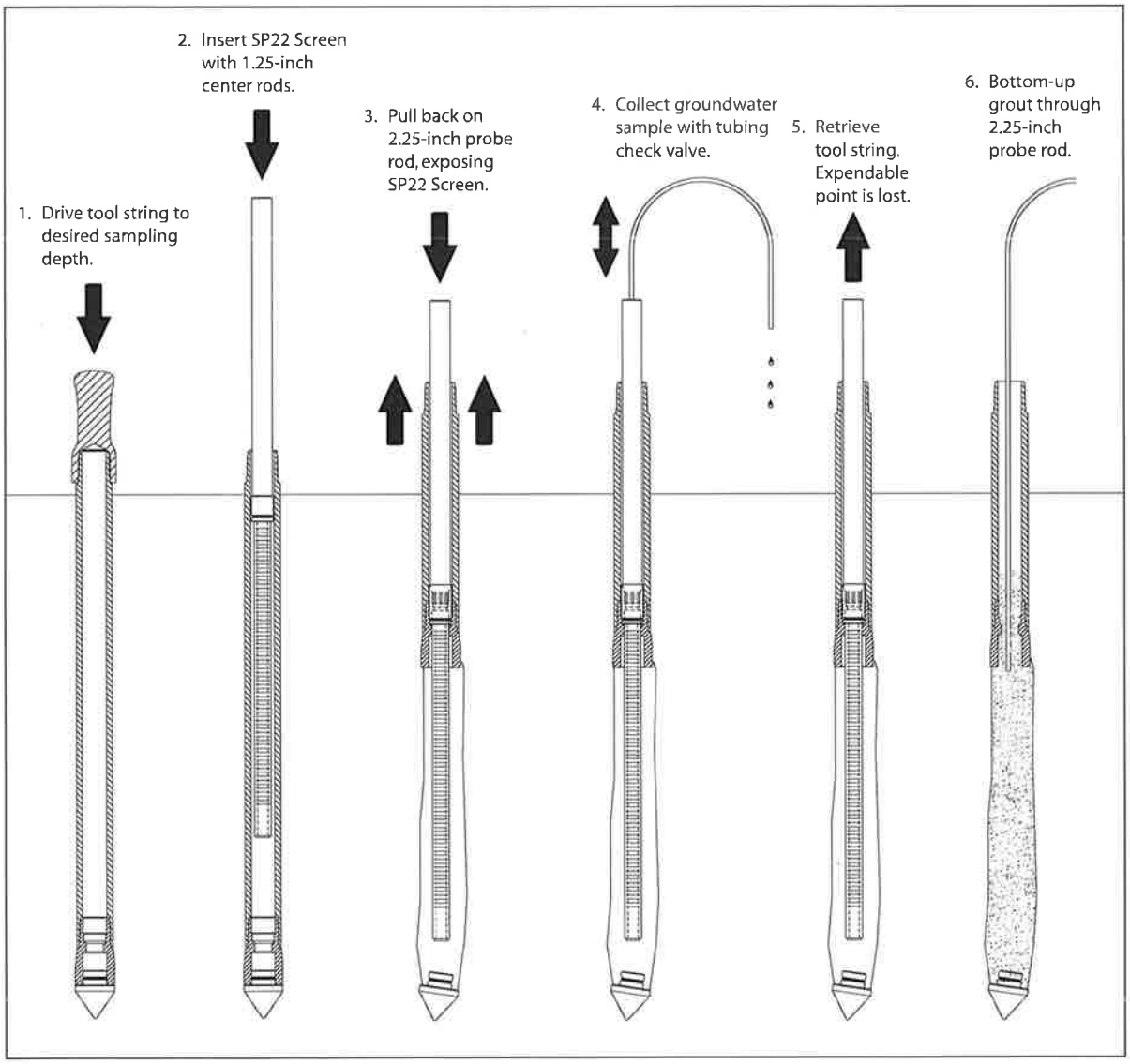
Geoprobe® Screen Point 22 Groundwater Sampler

GEOPROBE® SCREEN POINT 22 GROUNDWATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3173

PREPARED: April 2010



OPERATION OF THE GEOPROBE® SCREEN POINT 22 GROUNDWATER SAMPLER

Geoprobe® and Geoprobe Systems®, Macro-Core® and Direct Image® are Registered Trademarks of Kejr, Inc., Salina, Kansas

Screen Point 22 Groundwater Sampler is manufactured under U.S. Patent 5,612,498

1.0 OBJECTIVE

The objective of this procedure is to deploy a stainless steel or PVC screen at depth, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 22 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically powered machines that utilize static force and percussion or rotation to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform activities such as soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

Screen Point 22 (SP22) Groundwater Sampler: A direct push device consisting of a PVC or stainless steel screen that is lowered (post-run) to depth within a sealed string of steel probe rods and then deployed for the collection of representative groundwater samples. Upon deployment, up to 48 inches (1219 mm) of screen can be exposed to the formation. There is also an optional 12-inch screen that can be used. The Screen Point 22 Groundwater Sampler is designed for use with 2.25-inch probe rods and machines equipped with the more powerful GH60 and GH80 series hydraulic hammers. Operators with GH40 series hammers may choose to use this sampler in soils where driving is easier.

Rod Grip Pull System: An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with probe rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

2.2 Discussion (Fig. 2.1)

In this procedure, 2.25-inch probe rods are advanced into the subsurface with a Geoprobe® subsurface machine (Fig. 2.1, Step 1). While the tool string is advanced to depth, O-ring seals at each rod joint, the expendable point holder, and the expendable drive point provide a watertight system. This eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once the leading end of the 2.25-inch probe rods reaches the desired sampling interval, an SP22 screen is lowered to the bottom of the rods using a string of either 1.25-inch outside diameter (OD) light-weight center rods, 1.25-inch probe rods, or 0.75-inch schedule 40 flush-thread PVC riser (Fig. 2.1, Step 2). The 2.25-inch rods are then retracted while the SP22 screen is held in place with the 1.25-inch rods or PVC riser (Fig 2.1, Step 3). As the 2.25-inch tool string is retracted, the expendable point is released from the expendable point holder. The tool string and expendable point holder may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

The SP22 Sampler can also be used with the Geoprobe® DT22 system. (Fig. 2.2)

(continued on following page)

Expendable Drive Points
The SP22 system utilizes an SP22 Expendable Point Holder (33764) and standard 2.45-inch (62-mm) OD steel Expendable Drive Points for 2.25-inch probe rods (AT2015K). Extended Shank Expendable Drive Points (19442) are available for soft soil conditions where standard points may be advanced out of the point holder during percussion. A third option is to use a part number 43128 SP22 Expendable Point Holder along with 1.625-inch (41-mm) steel Expendable Drive Points (GW1555K). These smaller drive points are more economical to purchase and ship, but must not be used with GH80 Series Hydraulic Hammers as they may not stay seated during percussion.

Screens
Two types of screens have been developed for use in the Screen Point 22 Groundwater Sampler - a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm). These screens are available in nominal 48- and 12-inch lengths. Effective screen lengths for the 48- and 12-inch PVC screens are 48 inches (1219 mm) and 12 inches (305 mm), while 48- and 12-inch stainless steel screens have effective screen lengths of 43 inches (1092 mm) and 14 inches (356 mm) respectively. Both types of screens are recovered with the tool string after sampling.

The SP22 PVC Screen Head Adapter (37871) provides yet another screen option for the SP22 sampler. Using this adapter, a section of slotted 0.75-inch Schedule 40 PVC pipe may be lowered through the 2.25-inch probe rods using a string of flush-threaded 0.75-inch Schedule 40 PVC Riser. An SP22 PVC Screen Plug (38968) is installed in the leading end of the slotted pipe prior to use. The slotted pipe may be cut and the screen plug installed to provide custom screen lengths .

An O-ring is located at the top of each stainless screen and on the screen adapters. When a screen is deployed, this O-ring maintains a seal between the top of the screen and the inner wall of the probe rods or expendable point holder as indicated in Figure 2.1. As a result, any liquid entering the tool string must first pass through the screen.

Screens are constructed such that equipment can be inserted into the screen cavity for sample collection as noted in the following section and illustrated in Figure 2.1, Step 4. This makes direct sampling possible from anywhere within the saturated zone.

The inner rod string and screen are generally removed prior to grouting through the 2.25-inch rod string as shown in Figure 2.1, Steps 5-6. However, a removable plug in the lower end of the screens allows for grouting through flexible tubing extending out the bottom of the screen as with the Geoprobe® SP15/16 Groundwater Samplers if desired.

Sample Collection
Groundwater samples can be obtained from the SP22 screen in a number of ways. A common method utilizes 0.375-inch OD polyethylene (TB25L) or Teflon® (TB25T) tubing and a check valve assembly. The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is then pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An SP22 Check Valve Assembly (37893) is recommended if sampling through 1.25-inch light-weight center rods. The SP22 Check Valve Assembly is approximately 20 inches long to enable it to pass through the stepped diameters at each rod joint that may cause problems for other, shorter check valves.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to tubing that is inserted through the inner rods to within the SP22 screen. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP22 Sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

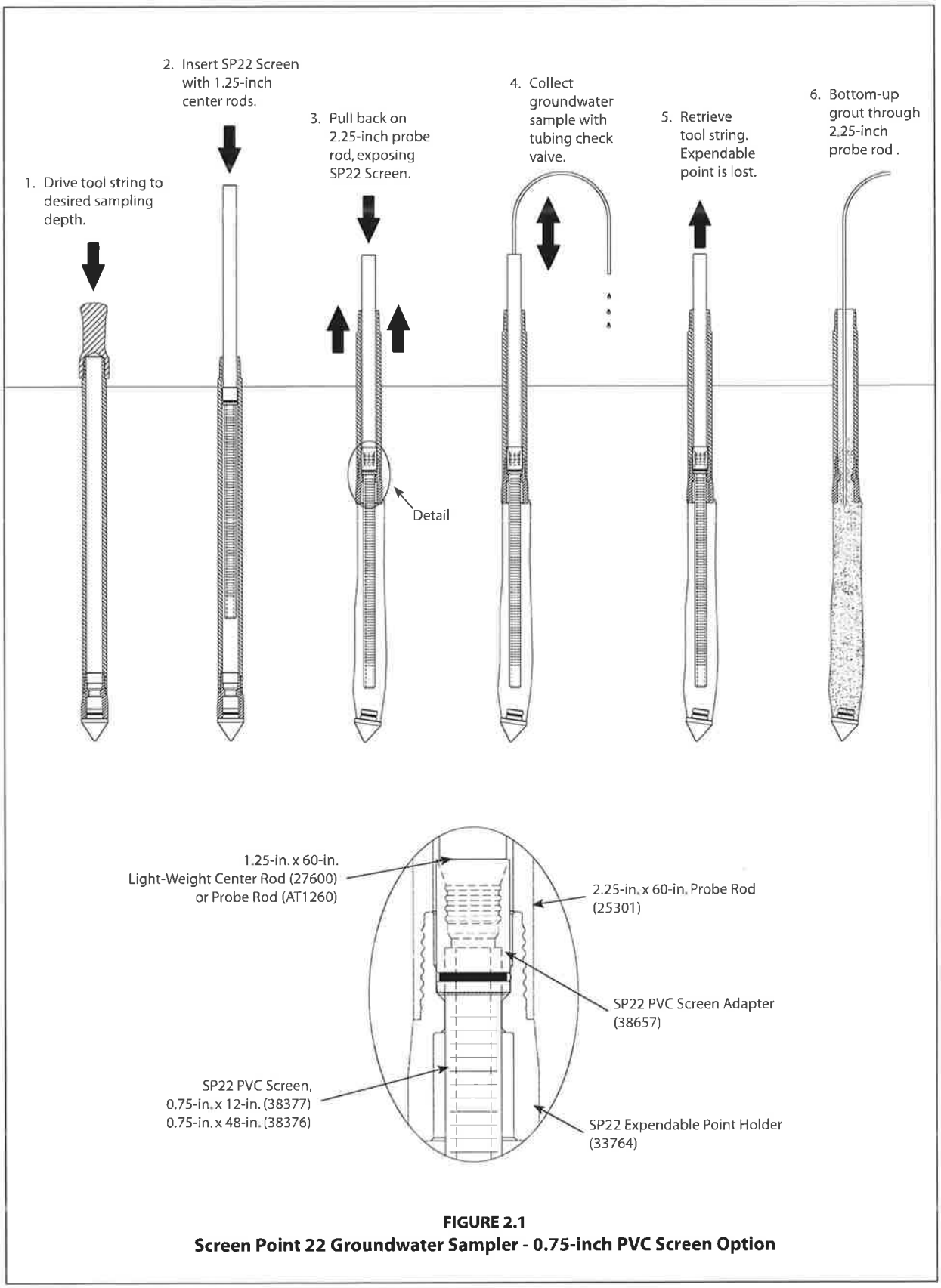


FIGURE 2.1
Screen Point 22 Groundwater Sampler - 0.75-inch PVC Screen Option

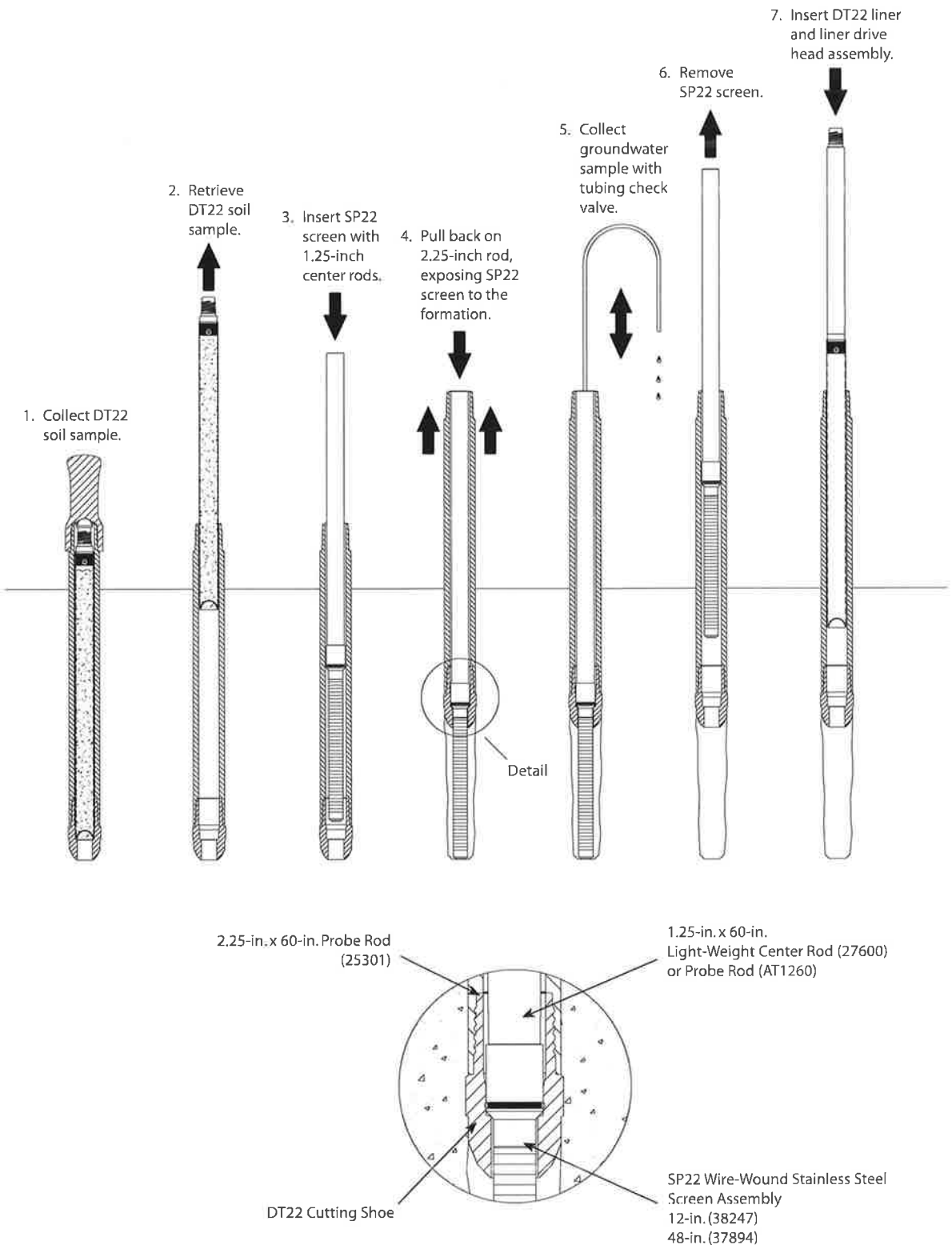


FIGURE 2.2
Screen Point 22 Groundwater Sampler Operation with DT22 Sampling System

3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 22 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP22 / 2.25-inch probe rod configurations. Additional rod sizes and accessories are available. Contact Geoprobe Systems® for information regarding tools and equipment options.

SP22 Sampler Parts	**Part Number**
SP22 Screen, Wire-Wound Stainless Steel, 4-Slot (48-in.)	37894
SP22 Screen, Wire-Wound Stainless Steel, 4-Slot (12-in.)	38247
Grout Plugs, PE (Pkg. of 25)	GW1552K
SP22 Screen, PVC, 10-Slot, 0.75-in. x 48-in	38376
SP22 Screen, PVC, 10-Slot, 0.75-in. x 48-inch, Kit (includes 2 each of 38376 and 38429)	*38664*
SP22 Screen, PVC, 10-Slot, 0.75-in. x 12-in	38377
SP22 Screen, PVC, 10-Slot 0.75-in. x 12-in., Kit (includes 2 each of 38377 and 38429)	*38667*
SP22 PVC Screen Plug	38968
SP22 PVC Screen Plug Kit (includes 10 of 38968)	*38530*
SP22 PVC Screen Adapter, 0.75-in. PVC x 1.25-in. Probe Rod Box	38657
SP22 PVC Screen Head Adapter, 0.75-in. (for flush-threaded 0.75-in. Schedule 40 PVC)	37871
SP22 O-ring Kit (Pkg. of 10 O-rings for SP22 PVC screen adapters and stainless steel screens)	37853
O-rings, 0.75-in. PVC Riser (Pkg. of 25)	GW4401R
SP22 Expendable Point Holder, 2.25-in. Probe Rods, AT2045K and 19442 Points	33764
SP22 Expendable Point Holder, 2.25-in. Probe Rods, GW1555 Points*	43128

Outer Casing (2.125-inch Probe Rods) and Inner Rod String	**Part Number**
Probe Rod, 2.25-in. x 60-in.	25301
Expendable Drive Points, Steel, 2.45-in. OD (Pkg. of 25)	AT2015K
Expendable Drive Points, Steel, 2.45-in. OD, extended shank	19442
Expendable Points, steel, 1.625-in. OD (Pkg. of 25)*	GW1555K
Drive Cap, 2.25-in. Probe Rods, Threadless, (for GH60 and GH80 Series Hammers)	31530
O-Rings, 2.25-in. Probe Rods (Pkg. of 25)	AT2100R
Rod Grip Handle, 2.25-in. Probe Rods, (for GH60 and GH80 Series Hammers)	29385
Light-Weight Center Rod, 1.25-in. x 60-in.	27600
Probe Rod, 1.25-in. x 60-in.	AT1260
O-ring, 1.25-in. rods (Pkg. of 25)	AT1250R
Rod Grip Handle, 1.25/1.5-in. Rods, (for GH60 and GH80 Series Hammers)	15554
PVC Riser, 0.75-in. Schedule 40 x 60-inch	11747
PVC Pipe, 0.75-in. Schedule 40 x 60-inch, 10-Slot	17474

Grout Accessories	**Part Number**
High-Pressure Nylon Tubing, 0.375-in. OD / 0.25-in. ID, 100-ft. (30 m)	11633
Grout Machine, Auxiliary-Powered	GS2200
Grout System Accessories Package, 2.25-in. rods	GS1015

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.375-in. OD, 500 ft	TB25L
Check Valve Assembly, 0.375-in. OD Tubing x 20 in. Long	37893
Water Level Meter, 0.438-in. OD Probe, 100 ft. cable	GW2000
Mechanical Bladder Pump**	MB470
Mini Bailer Assembly, Stainless Steel	GW41

* Not for use with GH80 Series Hydraulic Hammers

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.

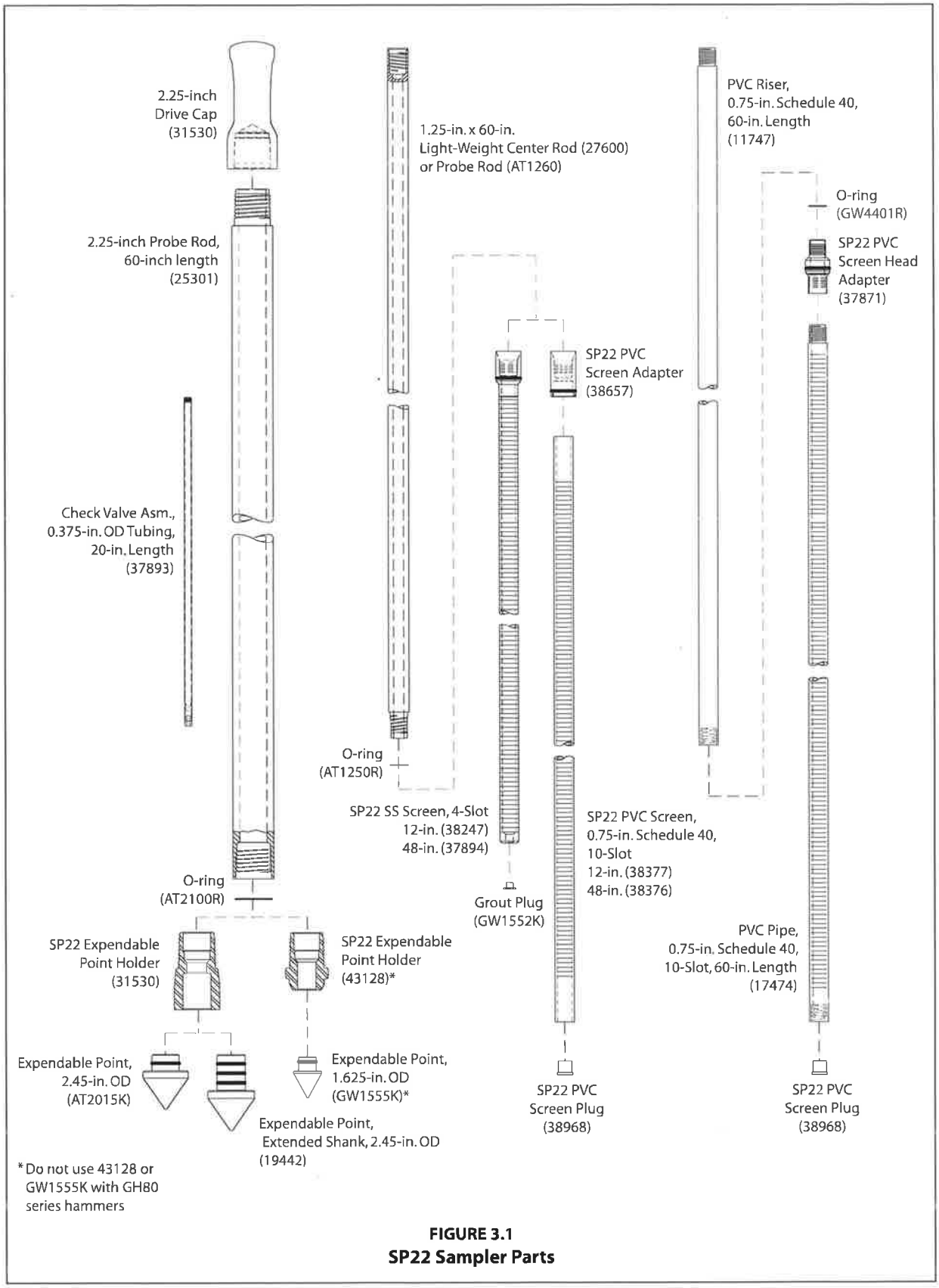


FIGURE 3.1
SP22 Sampler Parts

4.0 OPERATION

4.1 Basic Operation

The SP22 Sampler utilizes a stainless steel or PVC screen which is lowered (post-run) through an alloy steel 2.25-inch OD probe rod tool string. An expendable drive point is placed in an expendable point holder on the leading 2.25-inch probe rod prior to advancement (Fig. 4.1). This expendable point is removed and stays in the subsurface as the rods are pulled back to exposes the SP22 screen. O-rings on the probe rods , the expendable point holder, and the expendable drive point provide a watertight tool string which keeps contaminants out of the system as the 2.25-inch rods are driven to depth in preparation for installation of the SP22 screen.

Once the sampling interval is reached with the 2.25-inch probe rods, the stainless steel or PVC screen is lowered through the rods using 1.25-inch probe rods, 1.25-inch light-weight center rods, or 0.75-inch PVC riser pipe. The 2.25-inch tool string is then retracted while the screen is held in place with the inner rods or riser. The system is now ready for groundwater sampling. When sampling is complete, the inner rods and screen are removed for grouting during retrieval or the 2.25-inch rods. Alternatively, a removable plug is located in the bottom of the screens to allow grouting directly through the inner tool string with high-pressure tubing during retrieval.

4.2 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

4.3 Lead Rod Assembly (Fig. 4.1)

1. Place an O-ring on the expendable point holder.
2. Thread expendable point holder into the 2.25-inch probe rod.
3. Place an O-ring on a steel expendable drive point.
4. Firmly seat the expendable point in the expendable point holder.
5. Place 2.25-inch Drive Cap (31530) on the top of the 2.25-inch probe rod. The lead rod assembly is now ready to be driven to depth.

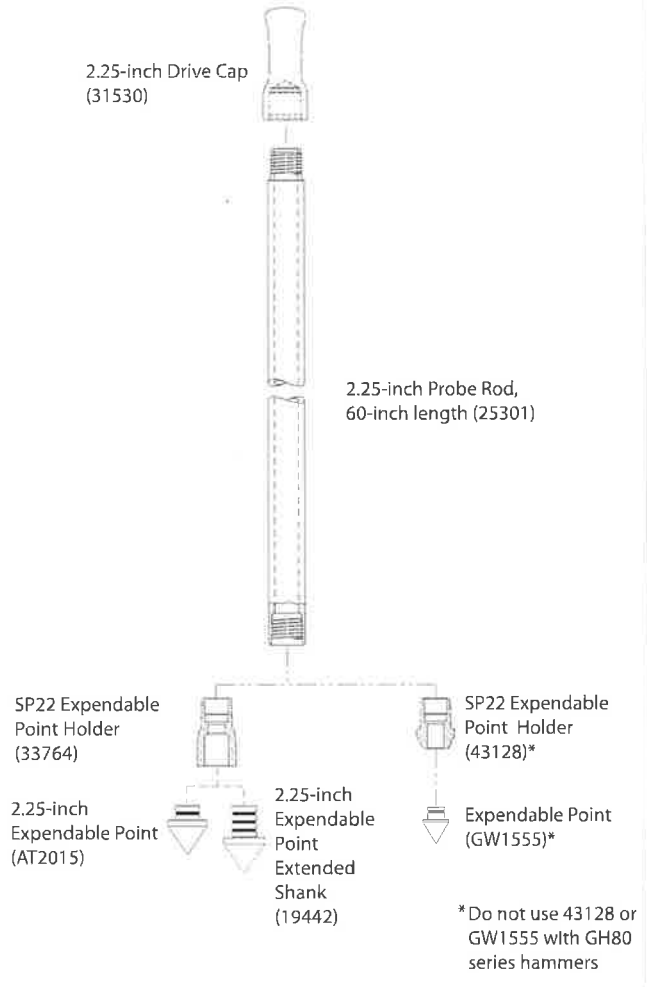


FIGURE 4.1
Lead Rod Assembly for the SP22 Groundwater Sampler

4.4 Advancing the Tool String (Fig. 4.2, step 1)

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

1. Drive first 2.25-inch probe rod (as assembled in section 4.3).

2. Advance the tool string at a slow speed for the first few feet to ensure that the string is aligned properly.

3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the driven probe rod. Distilled water may be used to lubricate the O-ring if needed.

   Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the tool string the entire length of the new rod.

4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.

5. Remove the drive cap and retract the probe derrick away from the tool string.

4.5 Screen Deployment (Fig 4.2, step 2 - 4)

1. Attach an SP22 stainless steel or PVC screen to a 1.25-inch probe rod, 1.25-inch light-weight center rod, or 0.75-inch flush-thread PVC riser using an SP22 PVC Screen Adapter (38657) or SP22 PVC Screen Head Adapter (37871) as shown in Figure 3.1. Note that the 38657 screen adapter is connected to the SP22 PVC screen using the setscrews provided with the adapter.

and lower it into the driven casing.

2. Lower the screen into the 2.25-inch probe rod casing and add rods or riser until the screen head contacts the bottom of the tool string.

3. Ensure that at least 48 inches (1219 mm) of rods or riser protrudes from the top 2.25-inch probe rod.

4. Maneuver the probe assembly into position for pulling.

5. Raise (pull) the outer 2.25-inch tool string while physically holding the screen in place with the inner 1.25-inch rods or 0.75-inch riser. A slight knock with the inner tool string will help to dislodge the expendable point and start the screen moving inside the probe rod.

   Raise the hammer and outer tool string to expose the desired length of screen. The inner rods will begin raising with the outer rods when the screen adapter contacts the necked portion of the expendable point holder or DT22 Cutting Shoe. Use care when deploying a PVC screen so as not to break the screen when it contacts the expendable point.

6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top 2.25-inch probe rod.

7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

   When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

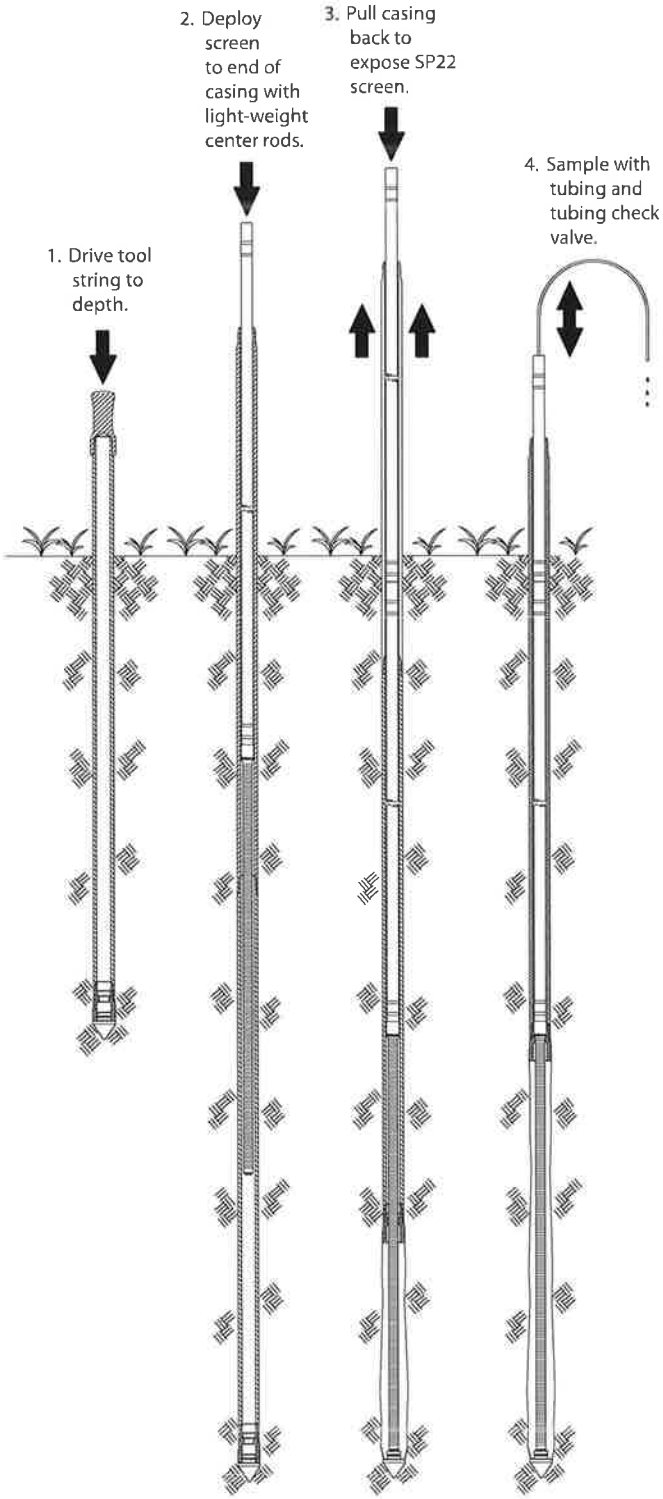


FIGURE 4.2
Screen Deployment for SP22 Sampler

4.6 Abandonment Grouting for SP22 Screens

The SP22 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of the SP22 screens, but the easiest method is to remove the inner string of rods; including the SP22 screen. A Grout Machine is then used to pump grout into the open probe hole as the outer casing is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations. (Figure 4.3)

1. Maneuver the probe assembly into position for pulling.

2. High-Pressure Nylon Tubing (11633) is inserted down through the probe rods through the bottom of the expendable point holder (Fig. 4.3).

   Note: *All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.*

3. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.

4. Repeat Step 5 until the tool string is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.

5. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.7 Retrieving the Screen Point 22 Sampler

If grouting is not required, the Screen Point 22 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (33622) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

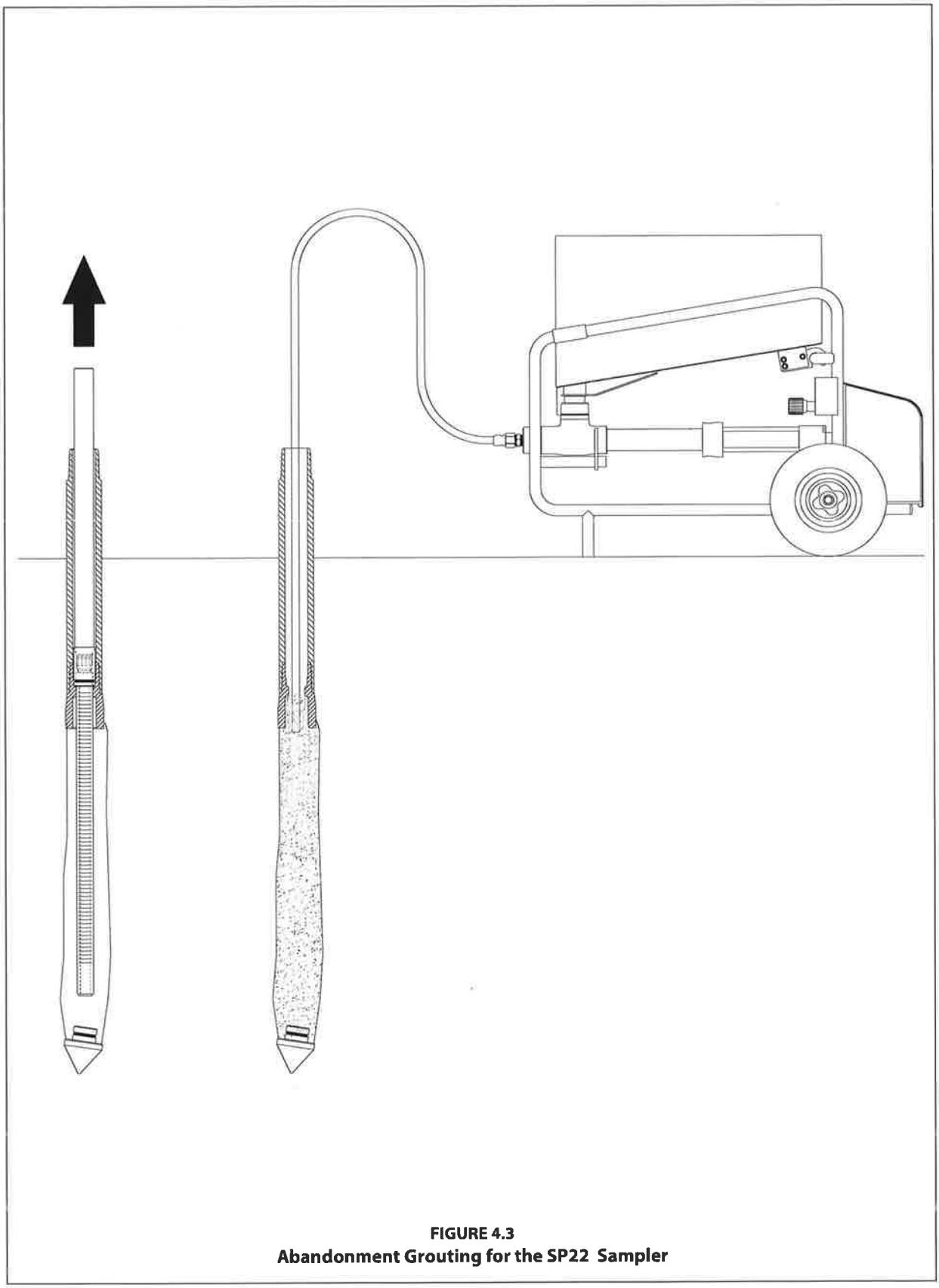


FIGURE 4.3
Abandonment Grouting for the SP22 Sampler

5.0 REFERENCES

American Society of Testing and Materials (ASTM), 2003. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. ASTM, West Conshocken, PA. (www.astm.org)

American Society of Testing and Materials (ASTM), 1993. ASTM 5299 *Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.* ASTM West Conshohocken, PA. (www.astm.org)

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Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.

U.S. Environmental Protection Agency (EPA), 2003. Environmental Technology Verification Report: Geoprobe Inc., Mechanical Bladder Pump Model MB470. Office of Research and Development, Washington, D.C. EPA/600R-03/086. August.

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.

A DIVISION OF KEJR, INC.

Corporate Headquarters
1835 Wall Street • Salina, Kansas 67401
1-800-GEOPROBE (1-800-436-7762) • Fax (785) 825-2097
www.geoprobe.com

ATTACHMENT B
Laboratory Standard Operating Procedures

Title: Per- and Polyfluorinated Substances (PFAS) in Water, Soils, Sediments and Tissue

[Method 537 (Modified), Method PFAS by LCMSMS Compliant with QSM 5.1 Table B-15]

Approvals (Signature/Date):

Robert Hrabak Technical Manager	4/12/18 Date
Joe Schairer Health & Safety Manager / Coordinator	4/13/2018 Date
Lisa Stafford Quality Assurance Manager	4/10/2018 Date
Crystal Pollock Laboratory Manager	4.11.18 Date

1. SCOPE AND APPLICATION

1.1. This procedure describes the analysis of water, soil, sediment, and tissue samples for the following compounds using liquid chromatography / tandem mass spectrometry (LC/MS/MS).

Compound Name	Abbreviation	CAS #
Perfluoroalkylcarboxylic acids (PFCAs)		
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
Perfluoro-n-hexanoic acid	PFHxA	307-24-4
Perfluoro-n-heptanoic acid	PFHpA	375-85-9
Perfluoro-n-octanoic acid	PFOA	335-67-1
Perfluoro-n-nonanoic acid	PFNA	375-95-1
Perfluoro-n-decanoic acid	PFDA	335-76-2
Perfluoro-n-undecanoic acid	PFUdA (PFUnA)	2058-94-8
Perfluoro-n-dodecanoic acid	PFDoA	307-55-1
Perfluoro-n-tridecanoic acid	PFTrDA	72629-94-8
Perfluoro-n-tetradecanoic acid	PFTeDA (PFTA)	376-06-7
Perfluoro-n-hexadecanoic acid (non-routine analyte)	PFHxDA	67905-19-5
Perfluoro-n-octadecanoic acid (non-routine analyte)	PFODA	16517-11-6
Perfluorinated sulfonic acids (PFSAs)		
Perfluoro-1-butanesulfonic acid	PFBS	375-73-5
Perfluoro-1-pentanesulfonic acid	PFPeS	2706-91-1
Perfluoro-1-hexanesulfonic acid	PFHxS	355-46-4
Perfluoro-1-heptanesulfonic acid	PFHpS	375-92-8
Perfluoro-1-octanesulfonic acid	PFOS	1763-23-1
Perfluoro-nonanesulfonic acid	PFNS	8789-57-2
Perfluoro-1-decanesulfonic acid	PFDS	335-77-3
Perfluorinated sulfonamides (FOSA)		
Perfluoro-1-octanesulfonamide	FOSA	754-91-6
Perfluorinated sulfonamidoacetic acids (FOSAA)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid	EtFOSAA	2991-50-6
N-methylperfluoro-1-octanesulfonamidoacetic acid	MeFOSAA	2355-31-9
Fluorotelomer sulfonates (FTS)		
1H,1H,2H,2H-perfluorohexane sulfonate *(4:2)*	4:2 FTS	757124-72-4
1H,1H,2H,2H-perfluorooctane sulfonate *(6:2)*	6:2 FTS	27619-97-2
1H,1H,2H,2H-perfluorodecane sulfonate *(8:2)*	8:2 FTS	39108-34-4

Abbreviations in parenthesis are the abbreviations listed in Method 537, where they differ from the abbreviation used by the laboratory's LIMS.

1.2. Additional analytes supported by this method: The following analytes can be supported by this method under special request.

Compound Name	Abbreviation	CAS #
Fluorinated Replacement Chemicals		
Adona	Adona	958445-44-8
Perfluoro(2-propoxypropanoic) acid	HFPO-DA or GenX	13252-13-6
F53B (reported as the summation of the following)	F53B	NA
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonate	F53B major	73606-19-6
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonate	F5B minor	83329-89-9

1.3. The working range of the method is listed below. The linear range can be extended by diluting the extracts.

Matrix	Nominal Sample Size	Reporting Limit	Working Range
Water	250 mL	2.0 ng/L – 20 ng/L	2.0 ng/L - 400 ng/L
Soil/Sediment	5 g	0.2 ug/kg – 2.0 ug/kg	0.2 ug/kg - 40 ug/kg
Tissue	1 g	1.0 ug/kg – 10 ug/kg	1.0 ug/kg – 200 ug/kg

1.4. The procedure for the analysis of water samples via in line solid phase extraction (SPE) for a subset of the list in Section 1.1 using liquid chromatography / tandem mass spectrometry (LC/MS/MS) on a SCIEX 5500 is described in Attachment 1 of this SOP.

1.5. This procedure also includes direction for preparing and analyzing samples to determine “Total Oxidizable Precursors”, which may assist in improving understanding of potential PFAS environmental risk.

1.6. When undertaking projects for the Department of Defense (DoD) and/or the Department of Energy (DOE) the relevant criteria in QA Policy WS-PQA-021, “Federal Program Requirements” must be checked and incorporated.

2. SUMMARY OF METHOD

2.1. Water samples are extracted using a solid phase extraction (SPE) cartridge. PFAS are eluted from the cartridge with an ammonium hydroxide/methanol solution.

2.2. Soil/sediment/tissue samples are extracted with a KOH/methanol solution using an orbital shaker for 3 hours followed by sonication for 12 hours. The mixture is centrifuged and the solvent filtered.

2.3. The final 80:20 methanol:water extracts are analyzed by LC/MS/MS. PFAS are separated from other components on a C18 column with a solvent gradient program

using 20 mM ammonium acetate/water and methanol. The mass spectrometer detector is operated in the electrospray (ESI) negative ion mode for the analysis of PFAS.

2.4. An isotope dilution technique is employed with this method for the compounds of interest. The isotope dilution analytes (IDA) consist of carbon-13 labeled analogs, oxygen-18 labeled analogs, or deuterated analogs of the compounds of interest, and they are spiked into the samples at the time of extraction. This technique allows for the correction for analytical bias encountered when analyzing more chemically complex environmental samples. The isotopically labeled compounds are chemically similar to the compounds of concern and are therefore affected by sample-related interferences to the same extent as the compounds of concern. Compounds that do not have an identically labeled analog are quantitated by the IDA method using a closely related labeled analog.

2.5. Quantitation by the internal standard method is employed for the IDA analytes/recoveries. Peak response is measured as the area of the peak.

2.6. Samples for the "Total Oxidizable Precursor" assay (TOP) are analyzed in two phases – an aliquot is prepared and analyzed as a normal sample, and a second aliquot is subjected to oxidation with potassium persulfate and sodium hydroxide prior to solid phase extraction and analysis. The total perfluorocarboxylic acid value is determined for each aliquot, and the difference calculated.

3. DEFINITIONS

3.1. PFCAs: Perfluorocarboxylic acids

3.2. PFSAs: Perfluorinated sulfonic acids

3.3. FOSA: Perfluorinated sulfonamide

3.4. PFOA: Perfluorooctanoic acid

3.5. PFOS: Perfluorooctane sulfonic acid

3.6. MPFOA: Perfluoro-n-[1,2,3,4-13C4]octanoic acid. Carbon-13 labeled PFOA

3.7. MPFOS: Perfluoro-1-[1,2,3,4-13C4]octanesulfonic acid. Carbon-13 labeled PFOS

3.8. PTFE: Polytetrafluoroethylene (e.g., Teflon®)

3.9. SPE: Solid phase extraction

3.10. PP: Polypropylene

3.11. PE: Polyethylene

3.12. HDPE: High density polyethylene

3.13. AFFF: Aqueous Film Forming Foam

3.14. IDA: Isotope dilution analyte

3.15. Further definitions of terms used in this SOP may be found in the glossary of the Laboratory Quality Assurance Manual (QAM).

4. INTERFERENCES

4.1. PFAS have been used in a wide variety of manufacturing processes, and laboratory supplies should be considered potentially contaminated until they have been tested and shown to be otherwise. The materials and supplies used during the method validation process have been tested and shown to be clean. These items are listed below in Section 6.

4.2. To avoid contamination of samples, standards are prepared in a ventilation hood in an area separate from where samples are extracted.

4.3. PTFE products can be a source of PFOA contamination. The use of PTFE in the procedure should be avoided or at least thoroughly tested before use. Polypropylene (PP) or polyethylene (PE, HDPE) products may be used in place of PTFE products to minimize PFOA contamination.

4.3.1. Standards and samples are injected from polypropylene autosampler vials with polypropylene screw caps once. Multiple injections may be performed on Primers when conditioning the instrument for analysis.

4.3.2. Random evaporation losses have been observed with the polypropylene caps causing high IDA recovery after the vial was punctured and sample re-injected. For this reason, it is best to inject standards and samples once in the analytical sequence.

4.3.3. Teflon-lined screw caps have detected PFAS at low concentrations. Repeated injection from the same teflon-lined screw cap have detected PFNA at increasing concentration as each repeated injection was performed, therefore, it is best to use polypropylene screw caps.

4.4. Volumetric glassware and syringes are difficult to clean after being used for solutions containing high levels of PFOA. These items should be labeled for use only with similarly concentrated solutions or verified clean prior to re-use. To the extent possible, disposable labware is used.

4.5. Both branched and linear PFAS isomers can potentially be found in the environment. Linear and branched isomers are known to exist for PFOS, PFOA, PFHxS, PFBS, EtFOSAA, and MeFOSAA based upon the scientific literature. If multiple isomers are present for one of these PFAS they might be adjacent peaks that completely resolve or not, but usually with a deflection point resolved during peak integration. The later of these peaks matches the retention time of its labeled linear analog. In general, earlier peaks are the branched isomers and are not the result of peak splitting.

As of this writing, only PFOS, PFOA, and PFHxS are commercially available as technical mixtures. These reference standards of the technical mixtures for these specific PFAS are used to ensure that all appropriate peaks are included during peak integration.

4.6. In an attempt to reduce PFOS bias, it is required that *m/z* 499>80 transition be used as the quantitation transition.

4.7. Per the Certificate of Analysis for labeled perfluorohexadecanoic acid ($13C_2$-PFHxDA) produced by Wellington Laboratories, the stock standard contains roughly 0.3% of native perfluorohexadecanoic acid. This equates to roughly 0.30 ng/L or 0.015 ug/kg of perfluorohexadecanoic acid expected in all samples and blanks.

5. SAFETY

Employees must abide by the policies and procedures in the Corporate Safety Manual, Sacramento Supplement to the CSM, and this document. All work must be stopped in the event of a known or potential compromise to the health or safety of an associate. The situation must be reported **immediately** to a supervisor, the EH&S Staff, or a senior manager.

5.1. Specific Safety Concerns

5.1.1. Preliminary toxicity studies indicate that PFAS could have significant toxic effects. In the interest of keeping exposure levels as low as reasonably achievable, PFAS must be handled in the laboratory as hazardous and toxic chemicals.

5.1.2. Exercise caution when using syringes with attached filter disc assemblies. Application of excessive force has, upon occasion, caused a filter disc to burst during the process.

5.1.3. Laboratory procedures such as repetitive use of pipets, repetitive transferring of extracts and manipulation of filled separatory funnels and other glassware represent a significant potential for repetitive motion or other ergonomic injuries. Laboratory associates performing these procedures are in the best position to realize when they are at risk for these types of injuries. Whenever a situation is found in which an employee is performing the same repetitive motion, the employee shall immediately bring this to the attention

of their supervisor, manager, or the EH&S staff. The task will be analyzed to determine a better means of accomplishing it.

5.1.4. Eye protection that satisfies ANSI Z87.1 (as per the TestAmerica Corporate Safety Manual), laboratory coat, and nitrile gloves must be worn while handling samples, standards, solvents, and reagents. Disposable gloves that have been contaminated will be removed and discarded; other gloves will be cleaned immediately.

5.1.5. Perfluorocarboxylic acids are acids and are not compatible with strong bases.

5.1.6. The use of vacuum systems presents the risk of imploding glassware. All glassware used during vacuum operations must be thoroughly inspected prior to each use. Glass that is chipped, scratched, cracked, rubbed, or marred in any manner must not be used under vacuum. It must be removed from service and replaced.

5.1.7. Glass containers are not to be used for "tumbling" soil samples.

5.2. Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the SDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the SDS for each material before using it for the first time or when there are major changes to the SDS.

Material[1]	Hazards	Exposure Limit[2]	Signs and Symptoms of Exposure
Acetic Acid (3-2-1)	Corrosive Poison Flammable	10 ppm-TWA 15 ppm-STEL	Contact with concentrated solution may cause serious damage to the skin and eyes. Inhalation of concentrated vapors may cause serious damage to the lining of the nose, throat, and lungs. Breathing difficulties may occur.
Ammonium Hydroxide (3-0-0)	Corrosive Poison	50 ppm-TWA	Severe irritant. Effects from inhalation of dust or mist vary from mild irritation to serious damage to the upper respiratory tract. Symptoms may include sneezing, sore throat or runny nose. Contact with skin can cause irritation or severe burns and scarring with greater exposures. Causes irritation of eyes, and with greater exposures it can cause burns that may result in permanent damage, including blindness. Brief exposure to 5000 PPM can be fatal.

Material[1]	Hazards	Exposure Limit[2]	Signs and Symptoms of Exposure
Hexane (2-3-0)	Flammable Irritant	500 ppm-TWA	Inhalation of vapors irritates the respiratory tract. Overexposure may cause lightheadedness, nausea, headache, and blurred vision. Vapors may cause irritation to the skin and eyes.
Hydrochloric Acid (3-0-1)	Corrosive Poison	5 ppm (Ceiling)	Can cause pain and severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause deep ulcerations to skin, permanent eye damage, circulatory failure and swallowing may be fatal.
Methanol (2-3-0)	Flammable Poison Irritant	200 ppm (TWA)	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
Potassium Hydroxide (3-0-1)	Corrosive Poison		Severe irritant. Can cause severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause severe scarring of tissue, blindness, and may be fatal if swallowed.
Potassium Persulfate (2-0-1-OX)	Oxidizer	None	Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath. Causes irritation to skin and eyes. Symptoms include redness, itching, and pain. May cause dermatitis, burns, and moderate skin necrosis.
Sodium Hydroxide (3-0-1)	Corrosive Poison	2 mg/cm^3 (Ceiling)	Severe irritant. Can cause severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause severe scarring of tissue, blindness, and may be fatal if swallowed.
(1) Always add acid to water to prevent violent reactions. (2) Exposure limit refers to the OSHA regulatory exposure limit.			

6. EQUIPMENT AND SUPPLIES

6.1. 15 mL polypropylene test tubes with polypropylene screw caps.

6.2. 50 mL graduated plastic centrifuge tubes.

6.3. 125 mL HDPE bottles with HDPE screw caps.

6.4. 250 mL HDPE bottles with HDPE screw caps.

6.5. Analytical balance capable of accurately weighing to the nearest 0.0001g, and checked for accuracy each day it is used in accordance with WS-QA-0041.

6.6. Extract concentrator or nitrogen manifold with water bath heating to 50-55°C.

6.7. Syringe filter, Millipore Millex-HV 0.45 um, or equivalent. Do not use PTFE type filters.

6.8. 300 µL autosampler vials, polypropylene, with polypropylene screw caps, Waters PN 1860004112, or equivalent.

6.9. SPE columns

6.9.1. Phenomenex Strata SPE C18, 6 mL, 500 mg, part number 8B-S002-HCH, Waters SepPak C18, 1 to 10g, or equivalent.

6.9.2. Waters Oasis WAX 150 mg/6 cc (PN 186002493) for the cleanup of solids.

6.9.3. Waters Oasis WAX 500 mg/6 cc (PN 186004647) for extraction of PFAS from aqueous sample.

6.9.4. Phenomonex Gemini 3 µm C18 110Å, 50 X 2 mm, Part No. 00B-4439-B0.

6.9.5. Phenomonex Luna 5 µm C18(2) 100Å, 30 X 3 mm, Part No. 00A-4252-Y0.

6.10. Graphitized carbon (Envi-Carb™ or equivalent).

6.11. Vacuum manifold for Solid Phase Extraction (SPE).

6.12. Miscellaneous laboratory apparatus (beakers, test tubes, volumetric flasks, pipettes, etc.). These should be disposable where possible, or marked and segregated for high-level versus low-level use.

6.13. Water bath: Heated with concentric ring cover capable of temperature control (±5°C) up to 95°C. The bath must be used in a fume hood.

6.14. Plastic tub for an ice bath, AKRO-N.S.T. part No. 35-180 or equivalent.

6.15. pH indicator paper, wide range.

6.16. Bottle rotating apparatus for soil extractions.

6.17. Glass fiber filter, Whatman GF/F, catalog number 1825 090 or equivalent.

6.18. Liquid Chromatography/Tandem Mass Spectrometer (LC/MS/MS) – Either of the instruments described below, or equivalent, may be used for this method. Both HPLC are equipped with a refrigerated autosampler, an injection valve, and a pump capable of variable flow rate. The use of a column heater is required to maintain a stable

temperature throughout the analytical run. Data is processed using Chrom Peak Review, version 2.1 or equivalent.

6.18.1. Waters LC/MS/MS

This consists of a Waters Acquity UPLC system interfaced with a Waters Quattro Premier tandem mass spectrometer. The instrument control and data acquisition software is MassLynx version 4.1, or equivalent.

6.18.1.1. Analytical column: Waters Acquity UPLC BEH C18 1.7 um, 3.0 mm x 150 mm, Part No. 186004690,

6.18.1.2. PFAS Isolator column, Waters Acquity UPLC BEH Shield RP-18, 1.7 um, 2.1 mm x 50 mm, PN 186004476, or equivalent. This is plumbed between the UPLC pumps and autosampler valve to minimize PFAS background from the UPLC solvent lines and filters.

6.18.2. SCIEX LC/MS/MS

This system consists of a Shimadzu HPLC interfaced with a SCIEX 5500 Triple Quad MS. The instrument control and data acquisition software is SCIEX Analyst, version 1.6.3 or equivalent.

6.18.2.1. Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent.

6.18.2.2. Phenomenex Gemini C_{18} 3 um, 3.0 mm x 100 mm, Part No. 00D-4439-Y0, or equivalent.

6.18.2.3. PFAS Isolator column, Phenomenex Luna C_{18} 5 um, 50 mm x 4.6 mm, part no. 00B-4252-E0 or equivalent. This is plumbed between the UPLC pumps and autosampler valve to minimize PFAS background from the UPLC solvent lines and filters.

6.19. Preventive and routine maintenance is described in the table below

HPLC/MS/MS Preventative Maintenance	
As Needed: Change pump seals. Change in-line filters in autosampler (HPLC). Check/replace in-line frit if excessive pressure or poor performance. Replace column if no change following in-line frit change. Clean corona needle. Replace sample inlet tube in APCI (10.1 cm). Replace fused silica tube in ESI interface. Clean lenses. Clean skimmer. Ballast rough pump 30 minutes. Create all eluents in Reagent module, label eluent containers with TALS label and place 2nd label into maintenance log when put into use.	**Daily (When in use)** Check solvent reservoirs for sufficient level of solvent. Verify that pump is primed, operating pulse free. Check needle wash reservoir for sufficient solvent. Verify capillary heater temperature functioning. Verify vaporizer heater temperature. Verify rough pump oil levels. Verify turbo-pump functioning. Verify nitrogen pressure for auxiliary and sheath gasses. Verify that corona and multiplier are functioning.
Semi-Annually Replace rough-pump oil (4-6 months). Replace oil mist and odor elements. Replace activated alumina filter if applicable	**Annually** Vacuum system components including fans and fan covers. Clean/replace fan filters, if applicable.

7. REAGENTS AND STANDARDS

7.1. Reagent grade chemicals shall be used in all tests whenever available. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on the Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.1.1. Acetic acid, glacial

7.1.2. Ammonium acetate (20 mM in water): Prepared by weighing 1.509g of ammonium acetate and dissolving in 1L of water. The resultant solution is filtered through a 0.22um filter before use. This solution has volatile components, thus it should be replaced every 7 days or sooner.

7.1.3. Ammonium hydroxide (NH4OH), 0.3% in methanol: Prepared by diluting 12mL of ammonium hydroxide into 4L of methanol.

7.1.4. Hexane

7.1.5. Hydrochloric acid (HCl), 2.0 M solution in water

7.1.6. Hydrochloric acid (HCl), concentrated, reagent grade

7.1.7. Methanol

7.1.8. Potassium hydroxide (KOH), 0.4% in methanol: Prepared by weighing 16g of potassium hydroxide and dissolving in 4L of methanol.

7.1.9. Potassium persulfate, reagent grade

7.1.10. Ottawa Sand

7.1.11. Sodium hydroxide (NaOH), 0.1N, in water: Prepared by diluting 400mL of 1N NaOH into 3.6L of water for a total volume of 4L.

7.1.12. Sodium hydroxide (NaOH), 10N, reagent grade

7.1.13. Water, Nanopure or Millipore, must be free of interference and target analytes

7.2. Standards

7.2.1. PFAS are purchased as high purity solids (96% or greater) or as certified solutions. Standard materials are verified compared to a second source material at the time of initial calibration. The solid stock material is stored at room temperature or as specified by the manufacturer or vendor.

7.2.1.1. Per the Certificate of Analysis for labeled perfluorohexadecanoic acid ($13C_2$-PFHxDA) produced by Wellington Laboratories, the stock standard contains roughly 0.3% of native perfluorohexadecanoic acid. This equates to roughly 0.30 ng/L or 0.015 ug/kg of perfluorohexadecanoic acid expected in all samples and blanks.

7.2.2. If solid material is used for preparing a standard, stock standard solutions are prepared from the solids and are stored at 4 ± 2°C. Stock standard solutions should be brought to room temperature before using. Standards are monitored for signs of degradation or evaporation. Standard solutions must be replaced at least annually from the date of preparation.

7.2.3. PFBS, PFHxS, PFHpS, PFOS, PFDS, MPFOS, and many other PFAS are not available in the acid form, but rather as their corresponding salts, such as sodium or potassium. The standards are prepared and corrected for their salt content according to the equation below.

$Mass_{acid}$ = Measured $Mass_{salt}$ × MW_{acid} / MW_{salt}

Where: MW_{acid} is the molecular weight of PFAA

MW_{salt} is the molecular weight of the purchased salt.

7.2.4. For example, the molecular weight of PFOS is 500.1295 and the molecular weight of NaPFOS is 523.1193. Therefore, the amount of NaPFOS used must be adjusted by a factor of 0.956.

7.3. Calibration Standards

The calibration stock solution is prepared by diluting the appropriate amounts of PFCA and PFSA stock solutions in 80% methanol/water. The calibration stock solution is diluted with methanol to produce initial calibration standards. These are the normal calibration levels used. A different range can be used if needed to achieve lower reporting limits or a higher linear range.

7.4. Initial Calibration (ICAL) Levels (ng/mL)

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Perfluoroalkylcarboxylic acids (PFCAs)							
PFBA	0.5	1.0	5.0	20	50	200	400
PFPeA	0.5	1.0	5.0	20	50	200	400
PFHxA	0.5	1.0	5.0	20	50	200	400
PFHpA	0.5	1.0	5.0	20	50	200	400
PFOA	0.5	1.0	5.0	20	50	200	400
PFNA	0.5	1.0	5.0	20	50	200	400
PFDA	0.5	1.0	5.0	20	50	200	400
PFUdA	0.5	1.0	5.0	20	50	200	400
PFDoA	0.5	1.0	5.0	20	50	200	400
PFTrDA	0.5	1.0	5.0	20	50	200	400
PFTeDA	0.5	1.0	5.0	20	50	200	400
PFHxDA	0.5	1.0	5.0	20	50	200	400
PFODA	0.5	1.0	5.0	20	50	200	400
Perfluorinated sulfonic acids (PFSAs)							
PFBS	0.5	1.0	5.0	20	50	200	400
PFPeS	0.5	1.0	5.0	20	50	200	400
PFHxS *	0.5	1.0	5.0	20	50	200	400
PFHpS	0.5	1.0	5.0	20	50	200	400
PFOS *	0.5	1.0	5.0	20	50	200	400
PFNS	0.5	1.0	5.0	20	50	200	400
PFDS	0.5	1.0	5.0	20	50	200	400
Perfluorinated sulfonamides (FOSA)							
FOSA	0.5	1.0	5.0	20	50	200	400

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Perfluorinated sulfonamidoacetic acids (FOSAA)							
EtFOSAA	0.5	1.0	5.0	20	50	200	400
MeFOSAA	0.5	1.0	5.0	20	50	200	400
Fluorotelomer sulfonates (FTS)							
4:2 FTS	0.5	1.0	2.0	20	50	200	400
6:2 FTS	0.5	1.0	5.0	20	50	200	400
8:2 FTS	0.5	1.0	5.0	20	50	200	400
Labeled Isotope Dilution Analytes (IDA)							
13C4-PFBA	50	50	50	50	50	50	50
13C5-PFPeA	50	50	50	50	50	50	50
13C2-PFHxA	50	50	50	50	50	50	50
13C4-PFHpA	50	50	50	50	50	50	50
13C4-PFOA	50	50	50	50	50	50	50
13C5-PFNA	50	50	50	50	50	50	50
13C2-PFDA	50	50	50	50	50	50	50
13C2-PFUdA	50	50	50	50	50	50	50
13C2-PFDoA	50	50	50	50	50	50	50
18O2-PFHxS	50	50	50	50	50	50	50
13C4-PFOS	50	50	50	50	50	50	50
13C3-PFBS	50	50	50	50	50	50	50
13C2-PFTeDA	50	50	50	50	50	50	50
13C2-PFHxDA	50	50	50	50	50	50	50
13C8-FOSA	50	50	50	50	50	50	50
d5-EtFOSAA	50	50	50	50	50	50	50
d3-MeFOSAA	50	50	50	50	50	50	50
M2-4:2FTS ǂ	50	50	50	50	50	50	50
M2-6:2FTS	50	50	50	50	50	50	50
M2-8:2FTS	50	50	50	50	50	50	50
Internal Standard (IS)							
13C2-PFOA	50	50	50	50	50	50	50

* Both branched and linear isomers are used.

ǂ - This compound is used as a reverse surrogate for the TOP analysis.

Note: Sample extracts are in 80% MeOH/H_2O.

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Fluorinated Replacement Chemicals							
HFPO-DA	0.5	1.0	5.0	20	50	200	400
9Cl-PF3ONS (F53B major)	0.5	1.0	5.0	20	50	200	400
11Cl-PF3OUdS (F53B minor)	0.5	1.0	5.0	20	50	200	400

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Fluorinated Replacement Chemicals							
Adona	0.5	1.0	5.0	20	50	200	400
Labeled Isotope Dilution Analytes							
13C3-HFPO-DA	0.5	1.0	5.0	20	50	200	400

Note: Sample extracts are in 80% MeOH/H_2O.

***Note**: The above calibration limits are provided only as an example. The actual ICAL level used for each analytical batch will depend upon the LOQ requirements of the program. The concentration of the calibration solutions for non-concentrated extracts is 1/20th the levels indicated above.*

7.4.1. A technical (qualitative) grade PFOA standard which contains both linear and branched isomers is used as a retention time (RT) marker. This is used to integrate the total response for both linear and branched isomers of PFOA in environmental samples while relying on the initial calibration with the linear isomer quantitative standard This technical (qualitative) grade PFOA standard is analyzed initially, after an initial calibration when a new column is installed or when significant changes are made to the HPLC parameters.

7.5. Initial Calibration Verification Standard (ICV)

A second source solution for PFAS is purchased from the same vendor; the PFC-MXB contains most of the target analytes in this mixture and is used as an ICV. A few compounds are not available in this mixture, may not be available as another lot, and are not available from another vendor. For these analytes only, a second analyst may prepare a second source standard from the same source as the ICAL to produce an ICV. The recommended concentration of the ICV standard should be in the mid-range of the calibration curve. The concentration may be adjusted if the initial calibration levels are changed or altered. The IDA and IS are added at a fixed concentration of 50 ng/mL.

7.6. LCS/Matrix PFC Spike Solution, 20 ng/mL

The PFC spike solution is prepared by diluting all PFAS to produce a solution containing each PFAS at a concentration of 20 ng/mL in methanol.

7.7. PFC Isotope Dilution Analyte Solution, 50 ng/mL

The PFC-IDA solution is prepared by diluting all labeled PFAS to produce a solution containing each compound at a concentration of 50 ng/mL in methanol.

7.8. Reverse Surrogate Solution, 1000 ng/mL

The reverse surrogate solution is prepared by diluting M2-4:2 FTS to produce a solution containing this compound at a concentration of 1000 ng/mL in methanol. This is added to all samples for the TOP assay to monitor the efficiency of the oxidation process.

7.9. Internal Standard Solution, 250 ng/mL

The internal standard solution is prepared by diluting 13C2-PFOA to produce a solution containing this compound at a concentration of 250 ng/mL in methanol. This is added to all extracts prior to analysis. The internal standard solution used for the non-concentrated extracts is at a concentration of 50 ng/mL.

8. SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1. Water samples are collected in pre-cleaned 250 mL HDPE containers. Soil samples are collected in pre-cleaned 8 oz. HDPE containers. Other containers may also be suitable. Samples are chilled to 0 - 6°C for shipment to the laboratory.

8.1.1. Water samples collected from a known chlorinated source should be preserved with Trizma.

8.2. Samples are logged in following normal laboratory procedures and are stored under refrigeration at 0 - 6°C. Water samples must be extracted within 14 days of collection. Soil samples must also be extracted within 14 days of collection. Tissue samples must be extracted within 1 year of collection if stored at -20°C. Extracts must be refrigerated at 0 - 6°C, and analyzed within 40 days from extraction.

***Note**: As of this writing, Method 537 provides for a 14 day holding time for water samples preserved with Trizma buffer. The scientific literature indicates that perfluorinated substances are highly persistent in the environment. TestAmerica Sacramento has conducted time stability studies that support a 14 day holding time for aqueous samples with and without Trizma preservation. TestAmerica Denver has conducted stability studies indicating that medium- and low-level solutions of PFOA are stable for at least three months in polystyrene and polypropylene plastics at 0-6°C. The 14/40 day holding times given above are based on the stability study and general EPA convention for the holding time of extractable organic compounds in water and soil.*

9. QUALITY CONTROL

9.1. Initial Demonstration of Capability (IDOC)

The initial demonstration and method detection limit (MDL) studies described in Section 13 must be acceptable before analysis of samples may begin.

9.2. Batches are defined at the sample preparation step. Batches should be kept together through the whole analytical process as far as possible, but it is not mandatory to analyze prepared extracts on the same instrument or in the same sequence. Refer to the QC program document (WS-PQA-003) for further details of the batch definition.

9.2.1. The quality control batch is a set of up to 20 samples of the same matrix processed using the same procedure and reagents within the same time period. The quality control batch must contain a matrix spike/matrix spike

duplicate (MS/MSD), a laboratory control sample (LCS) and a method blank. Laboratory generated QC samples (Blank, LCS, MS/MSD) do not count toward the maximum 20 samples in a batch. Field QC samples are included in the batch count. In some cases, at client request, the MS/MSD may be replaced with a matrix spike and sample duplicate. If insufficient sample is available for an MS/MSD, an LCSD may be substituted if batch precision is required by the program or client. In the event that multiple MS/MSDs are run with a batch due to client requirements, the additional MS/MSDs do not count toward the maximum 20 samples in a batch.

9.3. One method blank (MB, laboratory reagent blank) must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. For aqueous samples, the method blank is an aliquot of laboratory reagent water. For solid samples, the method blank is an aliquot of Ottawa sand. The method blank is processed in the same manner and at the same time as the associated samples. Corrective actions must be documented on a Non-Conformance memo, and then implemented when target analytes are detected in the method blank above the reporting limit or when IDA recoveries are outside of the control limits. Re-extraction of the blank, other batch QC and the affected samples are required when the method blank is deemed unacceptable. See policy WS-PQA-003 for specific acceptance criteria.

9.3.1. If the MB produces a peak within the retention time window of any of the analytes, determine the source of the contamination and eliminate the interference before processing samples.

9.3.2. The method blank must not contain any analyte at or above the reporting limit, or at or above 10% of the measured concentration of that analyte in the associated samples, whichever is higher.

9.3.3. If there is no target analyte greater than the RL in the samples associated with an unacceptable method blank, the data may be reported with qualifiers. Such action should be taken in consultation with the client.

9.3.4. Re-extraction and reanalysis of samples associated with an unacceptable method blank is required when reportable concentrations are determined in the samples.

9.3.5. Refer to WS-PQA-003 for further details of the corrective actions.

9.3.6. Projects performed under the auspices of the DOD/DOE must meet QSM specific criteria for method blanks. Results are acceptable if the blank contamination is less than ½ of the reporting limit/LOQ for each analyte, or less than 1/10 of the regulatory limit, or less than 1/10 of the sample result for the same analyte, whichever is greater. If the method blank does not

meet the acceptance criteria, the source of contamination must be investigated and measures taken to correct, minimize or eliminate the problem. Reprepare and reanalyze all field and QC samples associated with the contaminated method blank.

9.4. A laboratory control sample (LCS) must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. The LCS is an aliquot of laboratory matrix (e.g. water for aqueous samples and Ottawa sand for solids) spiked with analytes of known identity and concentration. The LCS must be processed in the same manner and at the same time as the associated samples. Corrective actions must be documented on a Non-Conformance memo, then implemented when recoveries of any spiked analyte is outside of the control limits. Re-extraction of the blank, other batch QC, and all associated samples are required if the LCS is deemed unacceptable. See WS-PQA-0003 for specific acceptance criteria. The control limits for the LCS are stored in TALS.

9.5. A matrix spike/matrix spike duplicate (MS/MSD or MS/SD) pair must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. An MS/MSD pair is aliquots of a selected field sample spiked with analytes of known identity and concentration. The MS/MSD pair must be processed in the same manner and at the same time as the associated samples. Spiked analytes with recoveries or precision outside of the control limits must be within the control limits in the LCS. Corrective actions must be documented on a nonconformance memo, and then implemented when recoveries of any spiked analyte are outside of the control limits provided by TALS or by the client.

9.6. A duplicate control sample (LCSD or DCS) may be added when insufficient sample volume is provided to process an MS/MSD pair, or is requested by the client. The LCSD is evaluated in the same manner as the LCS. See WS-PQA-003 for specific acceptance criteria.

9.7. Initial calibration verification (ICV) –A second source standard is analyzed with the initial calibration curve. The concentration should be at the mid range of the curve.

Corrective actions for the ICV include:

- Rerun the ICV.
- Remake or acquire a new ICV.
- Evaluate the instrument conditions.
- Evaluate the initial calibration standards.
- Rerun the initial calibration.

9.8. Isotope Dilution Analytes

9.8.1. The IDA solution is added to each field and QC sample at the time of

extraction, as described in Section 11. As described in Section 7, this solution consists of isotopically labeled analogs of the analytes of interest.

9.8.2. IDA recoveries are flagged if they are outside of the acceptance limits (25–150%). Quantitation by isotope dilution generally precludes any adverse effect on data quality due to IDA recoveries being outside of the acceptance limits as long as the signal-to-nose ratio is greater than 10:1.

9.8.2.1. Evaluate data quality for usability, flag and submit a non-conformance memo for any analytes outside of the recovery criteria, and report if data is deemed not adversely effected.

9.8.2.2. Re-extraction of samples should be performed if the signal-to-noise for any IDA is less than 10:1 or if the IDA recoveries fall below 10%.

9.8.2.2.1. Re-extraction may be necessary under other circumstances when data quality has been determined to be adversely affected.

9.8.2.3. Projects performed under the auspices of the DoD/DOE must meet QSM 5.1 specific criteria for IDA recoveries which are 50-150%. If QC or field samples do not meet these criteria then re-extraction is required.

9.9. Internal Standard

9.9.1. The Internal Standard (IS) is added to each field and QC samples prior to analysis. The CCV IS response (peak area) must not deviate by more than 50% from the average response (peak area) of the initial calibration.

9.9.2. Sample IS response (peak area) must be within ±50% of the response (peak area) in the most recent CCV.

9.9.3. If the IS does not meet criteria, re-analyze the extract. If the IS meets criteria in the second analysis, report that analysis. If the IS does not meet criteria in the second analysis, report the first analysis with narration.

10. CALIBRATION

10.1. For details of the calculations used to generate the regression equations, and how to use the factors generated by these equations, refer to SOP CA-Q-P-003 “Calibration Curves and Selection of Calibration Points”.

10.2. Routine instrument operating conditions are listed in the table in Section 11.18.

10.3. Instrument Tuning

Instrument tuning is done initially when the method is first developed and thereafter as needed to maintain the sensitivity and selectivity of the method. Tuning is done by infusing each individual compound (native and IDA) into the mobile phase using a tee fitting at a point just before the entrance to the electrospray probe. The responses for the parent and daughter ions for each compound are observed and optimized for sensitivity and resolution. Mass assignments are reviewed and calibrated if necessary. The mass assignments must be within ± 0.5 amu of the values shown in the table in Section 11.18.

10.3.1. Once the optimal mass assignments (within ±0.5 amu of true) are made immediately following the initial tune, the lowest level standard from the initial calibration curve is assessed to ensure that a signal to noise ratio greater than 10 to 1 (S/N > 10:1) is achieved for each PFAS analyte. The first level standard from the initial calibration curve is used to evaluate the tune stability on an ongoing basis. The instrument mass windows are set initially at ± 0.5 amu of the true value; therefore, continued detection of the analyte transition with S/N > 10:1 serves as verification that the assigned mass remains within ± 0.5 amu of the true value, which meets the DoD/DOE QSM tune criterion. For QSM work, the instrument sensitivity check (section 10.12.4) is also evaluated to ensure that the signal to noise criteria is met.

10.4. A new calibration curve must be generated after major changes to the system or when the continuing calibration criteria cannot be met. Major changes include, but are not limited to, new columns or pump seals. A new calibration is not required after minor maintenance.

10.5. With the exception of the circumstances delineated in policy CA-Q-P-003, it is not acceptable to remove points from a calibration curve. In any event, at least five points must be included in the calibration curve. Average Response Factor and linear fit calibrations require five points, whereas Quadratic (second order) calibrations require six points.

10.6. A fixed injection volume is used for quantitation purposes and is to be the same for both the sample and standards.

10.7. All units used in the calculations must be consistently uniform, such as concentration in ng/mL.

10.8. Initial Calibration

10.8.1. A number of analytical standards of different analyte concentrations are used to generate the curve. Each standard is injected once to obtain the peak

response for each analyte at each concentration. These standards define the working range of the analysis.

10.8.1.1. A minimum of five analytical standards is used when using average response factor and/or linear calibration fits.

10.8.1.2. A minimum of six analytical standards is used when a quadratic fit is used to generate the curve.

10.8.2. Calibration is by average response factor, linear fit, or by quadratic fit. Quadratic fit is used for the analyte if the response is non-linear.

10.8.2.1. For average response factor (RFa), the relative standard deviation (RSD) for all compounds quantitated against an identically labeled analog must be < 35% for the curve to be valid.

10.8.2.2. For average response factor (RFa), the relative standard deviation (RSD) for all compounds quantitated against a closely related labeled analog IDA must be < 50% for the curve to be valid.

10.8.2.3. For linear fit, the intercept of the line must be less than ½ the reporting limit, and the coefficient of determination (r2) must be greater than or equal to 0.990 for the curve to be considered valid (or the correlation coefficient (r) > 0.995).

10.8.2.4. The Internal Standard (IS) response (peak area) must not deviate by more than 50% from the average response (peak area) of the initial calibration.

10.8.2.5. Projects performed under the auspices of the DoD/DOE must meet QSM 5.1 specific criteria for initial calibration: The %RSD of the RFS for all analytes must be <20%. Linear or non-linear calibrations must have r^2>0.99 for each analyte. Analytes must be within 70-130% of their true value for each calibration standard.

10.9. Calibration Curve Fits

10.9.1. Linear regression or quadratic curves may be used to fit the data to a calibration function. Detailed descriptions and formulas for each fitting type can be found in SOP CA-Q-P-003, “Calibration Curves and Selection of Calibration Points”.

10.9.2. The linear curve uses the following function:

Equation 1

$$y = bx + c$$

Where:

$$y = \frac{\text{Area (analyte)}}{\text{Area (IS)}} \times \text{Concentration (IS)}$$

x = concentration
b = slope
c = intercept

10.9.3. The quadratic curve uses the following function:

Equation 2

$$y = ax^2 + bx + c$$

Where y, x, b, and c are the same as above, and a = curvature.

10.9.4. Evaluation of Calibration Curves

The following requirements must be met for any calibration to be used:

- Response must increase with increasing concentration.
- The absolute value of the intercept of a regression line (linear or non-linear) at zero response must be less than the reporting limit.
- There should be no carryover at or above 1/2 MRL after a high CAL standard.

If these criteria are not met, instrument conditions and standards will be checked, and the ICAL successfully repeated before continuing.

10.9.5. Weighting of Calibration Points

In linear and quadratic calibration fits, the points at the lower end of the calibration curve have less absolute variance than points at the high concentration end of the curve. This can cause severe errors in quantitation at the low end of the calibration. Because accuracy at the low end of the curve is very important for this analysis, it is preferable to increase the weighting of the lower concentration points. 1/concentration or 1/x weighting is encouraged. Visual inspection of the line fitted to the data is important in selecting the best fit.

10.10. Initial Calibration Blank (ICB)

10.10.1. Immediately following the ICAL, a calibration blank is analyzed that consists of an injection of 80:20 methanol:water blank containing both IDA and IS.

10.10.2. The result for the calibration blank must be less than the reporting limit.

10.10.3. If the ICB is greater than the reporting limit then the source of contamination

must be identified and any necessary cleaning completed, and then the instrument should be recalibrated.

10.10.4. Projects performed under the auspices of the DoD/DOE must meet QSM 5.1 specific criteria for instrument blanks. One is required immediately following the highest standard analyzed and *daily prior to sample analysis*. The instrument blank must be < ½ the LOQ.

10.11. Initial Calibration Verification (ICV)

10.11.1. Following the ICAL and the ICB, an ICV standard obtained from a different source or vendor than the ICAL standards is analyzed. This ICV standard is a mid-range standard.

10.11.2. The recovery for the ICV must meet the appropriate following criteria:

10.11.2.1. The native analyte must be within or equal to 60-140% for all native analytes quantitated against an identically labeled analog IDA.

10.11.2.2. The native analyte must be within or equal to 50-150% for all native analytes quantitated against a closely related labeled analog IDA.

10.11.2.3. The IDA must be within or equal to 50-150%.

10.11.3. Projects performed under the auspices of the DoD/DOE must meet QSM 5.1 specific criteria for the ICV. Analyte concentrations must be within ±30% of their true values for all analytes, IDA and target.

10.11.4. See Section 9.7 for corrective actions in the event that the ICV does not meet the criteria above.

10.12. Continuing Calibration Verification (CCV)

Analyze a CCV at the beginning of a run, the end of a run, and after every 10 samples to determine if the calibration is still valid. The exception is after an acceptable curve and ICV are run 10 samples can be analyzed before a CCV is required. The CCVs are usually at the mid-level range of the curve and should vary throughout the run from low level (LOQ/RL) to mid level. The curve and ICV do not need to be run every day. To start an analytical run a CCV can be analyzed and if it meets acceptance criteria a run can be started. In addition, the low standard in the curve must be analyzed and must be within ± 50% of the expected value.

10.12.1. The recovery for the CCV standards must be equal to or within 60-140% for all natives quantitated against an identically labeled analog and equal to or

within 50% to 150% for all natives quantitated against a closely related labeled analog. The recovery for the IDA must be within or equal to 50-150%.

10.12.2. The Internal Standard (IS) response (peak area) must be within ± 50% from the response (peak area) from the midpoint of the initial calibration.

10.12.2.1. Sample IS response (peak area) must be within ± 50% of the response (peak area) in the most recent CCV.

10.12.3. If this is not achieved, the instrument has drifted outside the calibration limits. The instrument must be recalibrated.

10.12.4. Projects performed under the auspices of the DoD/DOE must meet QSM 5.1 specific criteria for CCV. All analyte concentrations must be within ± 30% of their true value. Additionally, prior to analysis and at least once every 12 hours an instrument sensitivity check (ISC/CCVL) must be analyzed. The analyte concentrations must be at LOQ and the concentrations must be within ± 30% of their true value. This can be used as a CCV.

11. PROCEDURE

11.1. One-time procedural variations are allowed only if deemed necessary in the professional judgment of a supervisor to accommodate variation in sample matrix, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using an Non-Conformance Memo (NCM). The NCM process is described in more detail in SOP WS-QA-0023. The NCM shall be filed in the project file and addressed in the case narrative.

Any deviations from this procedure identified after the work has been completed must be documented in an NCM, with a cause and corrective action described.

11.2. Water Sample Preparation

11.2.1. Visually inspect samples for the presence of settled and/or suspended sediment/particulate. Evaluate if the sample can be decanted or centrifuged; if not, contact the client for guidance. Filtering the sample can lead to a low bias.

11.2.2. If authorized by the client to filter the sample, filter the water sample through a glass fiber filter (Whatman GF/F Cat No 1825 090 or equivalent). Gravity or vacuum can be used to pass the sample through the filter. Prepare a filtration blank with any samples requiring filtration. File an NCM noting the need for filtration.

Warning: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.2.3. Weigh the sample container prior to extraction and then weigh the sample container after extraction to determine the initial volume. Unless otherwise directed by client, use the entire sample volume.

11.2.4. Prepare additional aliquots of a field sample for the MS/MSD, if requested.

11.2.5. Prepare two 250 mL aliquots of HPLC-grade water for the method blank and LCS.

11.2.6. Spike the LCS and MS/MSD (if requested) with 0.5 mL of the LCS/Matrix PFC Spike solution (Section 7.6). This will result in a sample concentration of 40 ng/L.

11.2.7. Add 0.5 mL of the IDA PFC solution (Section 7.7) into each sample and QC sample, for a fixed concentration of 50 ng/mL in the final sample vial.

11.3. Solid Phase Extraction (SPE) of Aqueous Samples

The automated Zymark Auto-Trace Workstation can be used as long as the program follows these conditions and passes the background check.

11.3.1. Condition the SPE cartridges (Waters WAX, 500 mg/6 cc) by passing the following without drying the column.

Note: *The cartridges should not be allowed to go dry until the final elution step with methanol. At all of the other transition steps, the solvent/sample level should be stopped at the top of the column before the next liquid is added.*

WARNING: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.3.2. Wash with 5.0 mL of 0.3% NH_4OH/methanol.

11.3.3. Wash with 5.0 mL of 0.1N NaOH/water. Close valve when ~ 200 uL remains on top to keep column wet. After this step, the columns cannot go dry until the completion of loading and rinsing samples.

11.3.4. Appropriately label the columns and add the reservoir to the column.

11.3.5. Add samples to the columns and with vacuum, pull the entire 250 mL aliquot of the sample through the cartridge at a rate of approximately 2 to 5 drops per second.

11.3.6. After the final loading of the sample but before completely passed through the column, rinse the SPE column with 1 mL of water.

11.3.7. After the sample and water rinse have completely passed through the cartridge, allow the column to dry well with vacuum for 15 minutes.

11.4. SPE Column Wash of Aqueous Samples with Hexane

11.4.1. Load the first 5 mL of hexane to soak for five minutes and then elute to waste.

11.4.2. Load the second 5 mL of hexane and elute to waste (without a soaking period).

11.4.3. Allow the column to dry with vacuum for 5 to 10 minutes. Columns must be dried before continuing.

11.5. SPE Elution of Aqueous Samples – using 15 mL polypropylene test tubes as receiving tubes in the SPE manifold.

11.5.1. Rinse sample bottles with 5 mL of 0.3% NH_4OH/methanol and transfer to the column reservoir onto the cartridge. Allow the solution to soak for 5 minutes and then elute into the 15 mL collection tube.

11.5.2. Repeat sample bottle to column reservoir rinse and cartridge elution with a second 5 mL aliquot of 0.3% NH_4OH/methanol. The total collection should be approximately 10 mL.

11.5.3. **Note: If the extracts will not be concentrated elute extract with a total of 8 mL of 0.3% NH_4OH/methanol.**

11.5.4. Proceed to Section 11.15.2 (Graphitized Carbon Cleanup) as needed. This required for all DoD/DOE extracts.

11.6. Extract Concentration for Aqueous Extracts (Note, if the extract will not be concentrated, proceed to Section 11.7.)

11.6.1. Prior to concentrating each sample, add 100 uL of water.

11.6.2. Concentrate each sample under a gentle stream of nitrogen until the methanol is evaporated and the 100 uL of water remains.

11.6.2.1. This blow down must take a minimum of 3.5 hours.

11.6.2.2. Extracts can not remain in the water bath longer than 5 minutes once concentrated.

11.6.3. Add 300 uL of methanol and mix the contents well using a vortex mixer.

11.6.4. Add 100 uL of Internal Standard (IS) 250 ng/mL concentration solution to each extract and vortex to mix.

11.6.5. This will create an extract with a final solvent composition of 80:20 methanol:water.

11.6.6. Transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.6.7. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps can not be used due to detection of low level concentration of PFAS.

11.7. Final volume for non-concentrated extract

11.7.1. If the extract does not undergo concentration add 0.5 mL of IS 50 ng/mL concentration and 2 mL of water to the extract. This will create an extract with a final solvent composition of 80:20 methanol:water.

11.7.1.1. Seal the test tube tightly. Invert container several times and then vortex. Allow extract to settle for 10 minutes prior to moving to the next step.

11.7.2. Transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.7.3. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps cannot be used due to detection of low level concentration of PFAS.

11.8. Soil, Sediment and Tissue Sample Preparation and Extraction

11.8.1. Visually inspect soil samples for homogeneity.

11.8.1.1. Projects performed under the auspices of the DoD/DOE must have the entire sample homogenized prior to subsampling in accordance with QSM 5.1 criteria (see SOP WS-QA-0018).

11.8.2. Weigh a representative 5 g aliquot of soil, sediment or 1 g of tissue sample into a 50 mL HDPE wide-mouth bottle. Weigh additional sample amounts for the matrix spike and matrix spike duplicate analyses if they are requested.

11.8.3. For the method blank and LCS matrix, use 5 g each of Ottawa sand or 0.1 g

of oil.

11.8.4. Spike the LCS and MS/MSD (if requested) with 1.0 mL of the LCS/Matrix PFC Spike solution (Section 7.6). This will result in a sample concentration of 4.0 ng/g.

11.8.4.1. Spike non-concentrated samples at 0.5 mL of LCS/Matrix PFC Spike Solution.

11.8.5. Add 1.0 mL of the IDA PFC solution (Section 7.7) into each sample and QC sample, for a fixed concentration of 50 ng/mL in the final sample vial.

11.8.5.1. Spike non-concentrated samples at 0.5 mL of IDA PFC Solution.

11.8.6. Cap the bottles and allow the spike to settle into the sample matrix. Gently shake the bottles to mix the spike into the matrix.

11.8.7. Add 20 mL of 0.4% KOH/methanol to each sample.

11.8.8. Shake each sample on an orbital shaker at room temperature for 3 hours.

11.8.9. Following the shaking, extract the samples in an ultrasonic water bath for an additional 12 hours.

11.8.10. After the completion of extraction, centrifuge each sample at 3500 rpm for 15 minutes.

11.8.11. Collect and decant the KOH/methanol extract to a new 50 mL centrifuge tube.

11.8.12. Add another 2 mL of 0.4% KOH/methanol solution to the residue, briefly shake to mix and centrifuge at 3500 rpm for 15 minutes.

11.8.13. Combine the rinsate to the first corresponding tubes.

11.8.14. To the final KOH/methanol extract, add 2 mL of water to each.

11.8.15. Concentrate the KOH/methanol/water extract under nitrogen to less than 2 mL, and dilute with water to 15 mL final volume.

11.8.16. Acidify with 80 uL of glacial acetic acid, and mix the contents well with vortex mixer. Check the pH to ensure pH is between 6 to 8.

11.8.17. Centrifuge at 3500 rpm for 15 minutes.

11.9. Solid Extract Cleanup by SPE

Set up WAX 150 mg/6 cc SPE columns for sample cleanup using vacuum manifold.

11.9.1. Condition the SPE cartridges by passing the following without drying the column.

Note: *The cartridges should not be allowed to go dry until the final elution step with methanol. At all of the other transition steps, the solvent/sample level should be stopped at the top of the column before the next liquid is added.*

WARNING: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.9.2. Wash with 5.0 mL of 0.3% NH_4OH/methanol.

11.9.3. Wash with 10 mL of 0.1N NaOH/water. Close valve when ~ 500uL remains on top of column to keep column wet. *After this step, the columns cannot go dry until the completion of loading and rinsing samples.*

11.9.4. Add extracts to the columns and with vacuum, pull the entire extracts through the cartridge at rate of approximately 3 to 5 drops per second.

11.9.5. Rinse the sample tube with 5 mL of water and add to the SPE column.

11.9.6. Dry the columns with vacuum for 15 minutes.

11.10. SPE Column Wash of Solid Extracts with Hexane

11.10.1. Load the first 5 mL of hexane to soak for five minutes, and elute to waste.

11.10.2. Load the second 5 mL of hexane and elute to waste (without a soaking period).

11.10.3. Allow the column to dry with vacuum for 10 minutes. Columns must be dried before continuing.

11.11. SPE Elution of Solid Extracts – using 15 mL polypropylene test tube as receiving tube in the SPE manifold.

11.11.1. Rinse extraction bottles with 5 mL of 0.3% NH_4OH/methanol and transfer to the column reservoir onto the cartridge. Allow the solution to soak for 5 minutes and then elute into the 15 mL collection tube.

11.11.2. Repeat extract bottle to column reservoir rinse and cartridge elution with a second 5 mL aliquot of 0.3% NH_4OH/methanol. The total collection should be approximately 10 mL.

11.11.3. **Note: If the extracts will not be concentrated elute extract with a total of 8 mL of 0.3% NH_4OH/methanol.**

11.11.4. Proceed to Section 11.15.2 (Graphitized Carbon Cleanup) as needed. This is required for all DoD/DOE extracts.

11.12. Extract Concentration for Solid Samples (Note, if the extract will not be concentrated, proceed to Section 11.7)

11.12.1. Prior to concentrating each sample, add 200 uL of water.

11.12.2. Concentrate each sample under a gentle stream of nitrogen until the methanol is evaporated and the 200 uL of water remains.

11.12.2.1. This blow down must take a minimum of 3.5 hours.

11.12.2.2. Extracts can not remain in the water bath longer than 5 minutes once concentrated.

11.12.2.3. Add 600 uL of methanol and mix the contents well using a vortex mixer.

11.12.2.4. Add 200 uL of Internal Standard (IS) 250 ng/mL concentration solution to each extract and vortex to mix.

11.12.3. Transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.12.4. Seal the vial with a polypropylene screw cap. *Note: Teflon lined caps can not be used due to detection of low level concentration of PFAS.*

11.13. Product/Dispersion Samples

11.13.1. Check the solubility of the material in both methanol and water

11.13.1.1. If the material is soluble in water, dilute 0.5 mL of sample into 250 mL of DI water and proceed to Section 11.3 (follow water extraction procedures). Fortify sample appropriately with IDA or PFC spike solution, see Section 11.2.

11.13.1.2. If the material is soluble in methanol, dilute 1 g (if solid) or 1 mL (if liquid) of material into 10 mL of methanol (MeOH).

11.13.1.2.1. If the material does not completely dissolve, contact your immediate supervisor.

11.13.2. Take 100 uL of the 10 mL solution and dilute it to 10 mL in MeOH.

11.13.3. Take a 1 mL aliquot of this solution (effective dilution of 1000x (1 mg for solid or 0.001 mL for liquid)) and fortify with 0.5 mL of labeled IDA solution (Section 7.7).

11.13.4. DO NOT PASS EXTRACT THROUGH SPE CARTIRIDGE (omit steps 11.9 – 11.11).

11.13.5. Proceed to Section 11.6 of this SOP for extract concentration.

11.14. TOP (Total Oxidizable Precursor) Assay for Aqueous Samples

11.14.1. Prepare 3-250 mL HDPE containers with HPLC grade water to create the needed QC Samples (MB, LCS/LCSD).

11.14.2. Prepare enough 125 mL HDPE containers as needed for all “Pre” and “Post” samples, including QC. Label each appropriately.

11.14.3. Spike the “Pre” and “Post” MB 125 mL containers with 25 uL of the reverse surrogate solution of M2-4:2 FTS (Section 7.8).

11.14.4. Spike the “Pre” and “Post” LCS/LCSD 125 mL containers with 0.5 mL of the LCS Spike solution (Section 7.6), both regular and “add-on”, and 25 uL of the reverse surrogate solution (Section 7.8).

11.14.5. Remove the methanol solvent from all Post QC sample 125 mL containers (MB and LCS/LCSD) by using N2 evaporation.

11.14.6. Add 2g of potassium persulfate and 1.9 mL of 10 M NaOH to each “Post” sample container.

11.14.7. Subsample 100 mL aliquots of water from each field sample and QC from the 250 mL containers into each of the corresponding 125 mL containers for both the “Pre” and “Post” samples. Spike all “Pre” and “Post” samples with 25uL of the reverse surrogate solution (Section 7.8).

11.14.8. Set aside all “Pre” sample containers.

11.14.9. Cap each “Post” sample container, invert 2-3 times prior to placing container into water bath.

11.14.10. Add 2g of potassium persulfate and 1.9 mL of 10N NaOH to each “Post” sample container.

11.14.11. Heat each “Post” sample container in a water bath (KD) at 85°C for 6 hours.

11.14.12. After digestion for 6 hours, place the “Post” sample containers in an ice bath for 30 minutes.

11.14.13. Adjust the pH of “Post” samples and associated QC aliquots to 7 with concentrated HCl. Use pH paper to determine the pH.

11.14.14. Spike both “Pre” and “Post” samples and their associated QC samples with 0.5 mL of PFC IDA solution (Section 7.7), both regular and add-on.

11.14.15. Use the following SPE procedure for both “Pre” and “Post” samples:

11.14.15.1. Set up WAX 150 mg/6 cc SPE columns for sample extraction using a vacuum manifold.

11.14.15.2. Establish a sample loading flow rate of 1 mL/minute for each port of the vacuum manifold, for as many ports as will be used simultaneously during sample loading.

11.14.15.3. Wash/condition the SPE column with 5 mL of 0.3% NH_4OH/Methanol, then 5 mL water.

11.14.15.4. Load 100 mL of sample onto the SPE cartridge at a flow rate of 1 mL/minute.

11.14.15.5. Add 5 mL rinse water

11.14.15.6. After the sample and water rinse have completely passed through the column, allow it to dry well using vacuum with a flow rate of 1 mL/minute for 15 minutes.

11.14.15.7. Wash the SPE column with 10 mL hexane rinse eluting all to waste.

11.14.15.8. Allow the column to dry well using vacuum with a flow rate of 1 mL/minute for 5 minutes. Columns must be dry before continuing.

11.14.15.9. Elute the samples into 15 mL polypropylene test tubes in the SPE manifold by rinsing each 125 mL sample container with 5 mL of 0.3% NH_4OH/methanol, and add to the SPE cartridge as eluent.

11.14.15.10. Repeat with another 5 mL of 0.3% NH_4OH/methanol.

11.14.15.11. Collect the 10 mL of eluent and concentrate per Section 11.6.

11.15. TOP (Total Oxidizable Precursor) Assay for Soil Samples

11.15.1. Weigh representative 2 g aliquots of soil for each “Pre” and “Post” sample into a 50 mL centrifuge tube.

11.15.2. For the method blank and LCS matrix, use 2 g each of Ottawa sand for each “Pre” and “Post” QC sample.

11.15.3. Add 20 mL of 0.4% KOH/methanol to each sample.

11.15.4. Shake each sample on an orbital shaker at room temperature for 3 hours.

11.15.5. Following the shaking, extract the samples in an ultrasonic water bath for an additional 12 hours.

11.15.6. After the completion of extraction, centrifuge each sample at 3500 rpm for 15 minutes.

11.15.7. Collect and decant the KOH/methanol extract to a new 50 mL centrifuge tube.

11.15.8. Add another 2 mL of 0.4% KOH/methanol solution to the residue, briefly shake to mix and centrifuge at 3500 rpm for 15 minutes.

11.15.9. Combine the rinsate to the first corresponding tubes.

11.15.10. Proceed to Section 11.16.2 (Envi-carb clean up)

11.15.11. To the final KOH/methanol extract, add 0.5 mL of water to each.

11.15.12. Concentrate the KOH/methanol/water extract under nitrogen to less than 0.25 mL.

11.15.13. Dilute extract up to 50 mL with water in the centrifuge tube and vortex.

11.15.14. Prepare enough 125 mL HDPE containers as needed for all “Pre” and “Post” samples, including QC. Label each appropriately.

11.15.15. Spike the “Pre” and “Post” MB 125 mL containers with 25 uL of the reverse surrogate solution of M2-4:2 FTS (Section 7.8).

11.15.16. Spike the “Pre” and “Post” LCS/LCSD 125 mL containers with 0.5 mL of the LCS Spike solution and 25 uL of the reverse surrogate solution (Section 7.8).

11.15.17. Remove the methanol solvent from all “Post” QC sample 125 mL containers (MB and LCS/LCSD) by using N2 evaporation.

11.15.18. Add 2g of potassium persulfate and 1.9 mL of 10N NaOH to each “Post” sample container.

11.15.19. Transfer extract from the centrifuge tube to the appropriate 125 mL container.

11.15.20. Rinse the centrifuge container with an additional 50 mL of water and transfer to the appropriate 125 mL container.

11.15.21. Set aside all “Pre” sample containers.

11.15.22. Cap each “Post” sample container, invert 2-3 times prior to placing container into water bath.

11.15.23. Heat each “Post” sample container in a water bath (KD) at 85°C for 6 hours.

11.15.24. After digestion for 6 hours, place the “Post” sample containers in an ice bath for 30 minutes.

11.15.25. Adjust the pH of “Post” samples and associated QC aliquots to 7 with concentrated HCl. Use pH paper to determine the pH.

11.15.26. Spike both “Pre” and “Post” samples and their associated QC samples with 0.5 mL of PFC IDA solution (Section 7.7).

11.15.27. Use the following SPE procedure for both “Pre” and “Post” samples:

11.15.27.1. Set up WAX 150 mg/6 cc SPE columns for sample extraction using a vacuum manifold.

11.15.27.2. Establish a sample loading flow rate of 1 mL/minute for each port of the vacuum manifold, for as many ports as will be used simultaneously during sample loading.

11.15.27.3. Wash/condition the SPE column with 5 mL of 0.3% NH_4OH/Methanol, then 5 mL water.

11.15.27.4. Load 100 mL of sample onto the SPE cartridge at a flow rate of 1 mL/minute.

11.15.27.5. Add 5 mL rinse water

11.15.27.6. After the sample and water rinse have completely passed through the column, allow it to dry well using vacuum with a flow rate of 1 mL/minute for 15 minutes.

11.15.27.7. Wash the SPE column with 10 mL hexane rinse eluting all to waste.

11.15.27.8. Allow the column to dry well using vacuum with a flow rate of 1 mL/minute for 5 minutes. Columns must be dry before continuing.

11.15.27.9. Elute the samples into 15 mL polypropylene test tubes in the SPE manifold by rinsing each 125 mL sample container with 5 mL of 0.3% NH_4OH/methanol, and add to the SPE cartridge as eluent.

11.15.27.10. Repeat with another 5 mL of 0.3% NH_4OH/methanol.

11.15.27.11. Collect the 10 mL of eluent and concentrate per Section 11.6.

11.15.27.12. Note: If the extracts will not be concentrated elute extract with a total of 8 mL (2 4 mL rinses) of 0.3% NH_4OH/methanol.

11.16. Other Types of Sample Cleanup

11.16.1. Freezing technique to remove lipids.

If samples contain lipids then freeze the methanolic extract and QC extracts at -20^{o}C for at least 1 hour. Collect the solvent layer.

11.16.2. Cleanup with graphitized carbon will be applied to all samples as needed but is required for all DoD/DOE extracts.

11.16.2.1. Add 100 mg of graphitized carbon to each sample extract and QC extracts.

11.16.2.2. Shake vigorously and then let sit for 10 minutes.

11.16.2.3. Centrifuge each sample for 2 minutes at 1000 rpm.

11.16.2.4. Decant the solvent layer

11.16.2.5. Proceed to Section 11.6, 11.7 or 11.12 as applicable.

11.17. AFFF Sample Preparation

11.17.1. QC for AFFF samples consists of a method blank, a laboratory control sample and a sample or matrix duplicate only. No matrix spike or matrix spike duplicate is needed.

11.17.2. Perform a 1,000,000 X serial dilution of the AFFF sample. Dilute 1 mL of AFFF sample to 1L with laboratory supplied water. Then dilute 1mL of this dilution to 1L with laboratory supplied water.

11.17.2.1. Be sure to retain all dilutions should the initial analysis warrant re-analysis at higher concentration.

11.17.3. Subsample 2.0 mL of this dilution and fortify with 0.5 mL IDA solution and 0.5mL of IS (50 ng/mL) solution: then add 7.0 mL of methanol.

11.17.4. Transfer a portion of the sample to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the sample for re-injection or dilution.

11.18. Instrument Analysis

Suggested operating conditions are listed in Tables 1-7 for the Waters and SCIEX LCMS systems:

Table 1 - Recommended Instrument Operating Conditions

HPLC Conditions (Waters Acquity UPLC)					
Column (Column temp = 50°C)	Waters Acquity BEH 1.7µm C18, 3.0 x 150 mm				
Mobile Phase Composition	A = 20 mM Ammonium Acetate in Water B = Methanol				
Gradient Program	**Time**	**%A**	**%B**	**Curve**	**Flow Rate - mL/min.**
	0	98	2	6	0.30
	1	98	2	6	0.30
	2	50	50	6	0.30
	12	10	90	6	0.30
	12.5	0	100	6	0.30
	16	0	100	6	0.30
	16.2	98	2	6	0.30
	Maximum pressure limit = 15,000 psi				
Injection Size	10 µL (fixed amount throughout the sequence)				
Run Time	~20 minutes				
Mass Spectrometer Interface Settings (Quattro Premier XE)					
MS Interface Mode	ESI Negative Ion. Minimum of 10 scans/peak.				
Capillary (kV)	2.8				
Cone (V)	Varies from 8.0 to 65				
Extractor (V)	3				
Source Temp	135ºC				
Desolvation Temp	350ºC				
Cone Gas (nitrogen) Flow	25 L/hour				
Desolvation Gas (nitrogen) Flow	1100 L/hour				

Table 2 - Recommended Instrument Operating Conditions						
Mass Spectrometer Scan Settings (Quattro Premier XE)						
Compound	Comments	Reaction (MRM)	Dwell (sec)	Cone Volt.	Col. Energy	Function Number
PFBA	Native analyte	213 > 169	0.02	8	10	1
13C4-PFBA	IDA	217 > 172	0.02	12	10	1
PFPeA	Native analyte	263 > 219	0.02	10	10	2
13C5-PFPeA	IDA	268 > 223	0.02	11	9	2
PFBS	Native analyte	299 > 80	0.02	45	35	2
PFBS_2	Native analyte	299 > 99	0.02	45	35	2
13C3-PFBS	IDA	302 > 83	0.02	45	35	2
PFHxA	Native analyte	313 > 269	0.02	10	10	3
PFHxA_2	Native analyte	313 > 119	0.02	10	10	3
13C2-PFHxA	IDA	315 > 270	0.02	12	9	3
PFHpA	Native analyte	363 > 319	0.02	10	10	4
PFHpA_2	Native analyte	363 > 169	0.02	10	10	4
13C4-PFHpA	IDA	367 > 322	0.02	12	10	4
PFHxS	Native analyte	399 > 80	0.02	55	35	4
PFHxS_2	Native analyte	339 > 99	0.02	55	35	4
18O2-PFHxS	IDA	403 > 84	0.02	50	40	4
PFOA	Native analyte	413 > 369	0.02	12	10	5
PFOA_2	Native analyte	413 > 169	0.02	12	10	5
13C2-PFOA	IS	415 > 370	0.02	12	12	5
13C4-PFOA	IDA	417 > 372	0.02	12	12	5
PFHpS	Native analyte	449 > 80	0.02	60	38	5
PFHpS_2	Native analyte	449 > 99	0.02	60	38	5
PFNA	Native analyte	463 > 419	0.02	16	10	7
PFNA_2	Native analyte	463 > 169	0.02	16	10	7
13C5-PFNA	IDA	468 > 423	0.02	12	12	7
PFOS	Native analyte	499 > 80	0.02	60	40	6
PFOS_2	Native analyte	499 > 99	0.02	60	40	6
PFNS	Native analyte	549 > 80	0.02	60	40	6
PFNS_2	Native analyte	549 > 99	0.02	60	40	6
13C4-PFOS	IDA	503 > 80	0.02	35	48	6
PFDA	Native analyte	513 > 469	0.02	16	12	8
PFDA_2	Native analyte	513 > 169	0.02	16	12	8
13C2-PFDA	IDA	515 > 470	0.02	14	12	8
PFUdA	Native analyte	563 > 519	0.02	15	12	10
PFUdA_2	Native analyte	563 > 169	0.02	15	12	10
13C2-PFUdA	IDA	565 > 520	0.02	14	12	10
PFDS	Native analyte	599 > 80	0.02	74	48	10
PFDS_2	Native analyte	559 > 99	0.02	74	48	10
FOSA	Native analyte	498 > 78	0.02	40	32	9

Table 2 - Recommended Instrument Operating Conditions						
Mass Spectrometer Scan Settings (Quattro Premier XE)						
Compound	Comments	Reaction (MRM)	Dwell (sec)	Cone Volt.	Col. Energy	Function Number
13C8-FOSA	IDA	506 > 78	0.02	48	32	9
PFDoA	Native analyte	613 > 569	0.02	15	14	11
PFDoA_2	Native analyte	613 > 169	0.02	15	14	11
13C2-PFDoA	IDA	615 > 570	0.02	16	12	11
PFTrDA	Native analyte	663 > 619	0.02	12	12	11
PFTrDA_2	Native analyte	663 > 169	0.02	12	12	11
PFTeDA	Native analyte	713 > 169	0.02	12	18	11
PFTeDA_2	Native analyte	713 > 219	0.02	12	18	11
13C2-PFTeDA	IDA	715 > 670	0.02	15	15	11
PFHxDA	Native analyte	813 > 769	0.02	18	15	12
PFHxDA_2	Native analyte	813 > 169	0.02	18	15	12
PFODA	Native analyte	913 > 869	0.02	20	16	12
PFODA_2	Native analyte	913 > 169	0.02	20	16	12
13C2-PFHxDA	IDA	815 > 770	0.02	18	15	12
EtFOSAA	Native analyte	584 > 419	0.02	35	20	9
d5-EtFOSAA	IDA	589 > 419	0.02	30	25	9
MeFOSAA	Native analyte	570 > 419	0.02	30	28	9
d3-MeFOSAA	IDA	573 > 419	0.02	30	25	9
4:2FTS	Native analyte	327 > 307	0.02	40	30	5
M2-4:2FTS	Reverse Surrogate	329 > 81	0.02	40	30	5
6:2FTS	Native analyte	427 > 407	0.02	40	30	5
M2-6:2FTS	IDA	429 > 81	0.02	40	28	5
8:2FTS	Native analyte	527 > 507	0.02	40	28	8
M2-8:2FTS	IDA	529 > 81	0.02	40	28	8

Table 3 - Recommended Instrument Operating Conditions				
Retention Times & Quantitation (Quattro Premier XE)				
Native Compounds	**Typical Native RT (minutes)**	**IS analog**	**Typical IDA RT (minutes)**	**Quantitation Method**
PFBA	4.77	13C4-PFBA	4.79	Isotope Dilution
PFPeA	5.90	13C5-PFPeA	5.92	Isotope Dilution
PFBS	6.01	13C3-PFBS	6.01	Isotope Dilution
PFHxA	7.22	13C2-PFHxA	7.25	Isotope Dilution
PFPeS	7.20	18O2-PFHxS	8.64	Isotope Dilution
PFHpA	8.57	13C4-PFHpA	8.59	Isotope Dilution
PFHxS	8.60	18O2-PFHxS	8.64	Isotope Dilution
PFOA	9.80	13C4-PFOA	9.83	Isotope Dilution
PFHpS	9.80	13C4-PFOS	10.90	Isotope Dilution
PFNA	10.88	13C5-PFNA	10.92	Isotope Dilution
PFOS	10.87	13C4-PFOS	10.90	Isotope Dilution
PFNS	11.70	13C4-PFOS	10.90	Isotope Dilution
PFDA	11.82	13C2-PFDA	11.86	Isotope Dilution
FOSA	12.41	13C8-FOSA	12.46	Isotope Dilution
PFDS	12.57	13C4-PFOS	10.90	Isotope Dilution
PFUdA	12.62	13C2-PFUdA	12.66	Isotope Dilution
PFDoA	13.32	13C2-PFDoA	13.34	Isotope Dilution
PFTrDA	13.91	13C2-PFDoA	13.34	Isotope Dilution
PFTeDA	14.39	13C2-PFTeDA	14.39	Isotope Dilution
PFHxDA	15.16	13C2-PFHxDA	15.16	Isotope Dilution
PFODA	15.57	13C2-PFHxDA	15.16	Isotope Dilution
EtFOSAA	12.63	d5-EtFOSAA	12.62	Isotope Dilution
MeFOSAA	12.3	d3-MeFOSAA	12.28	Isotope Dilution
4:2FTS	7.02	13C3-PFBS	6.01	Isotope Dilution
6:2FTS	10.08	M2-6:2FTS	10.08	Isotope Dilution
8:2FTS	11.95	M2-8:2FTS	11.95	Isotope Dilution

Table 4 - Recommended Instrument Operating Conditions				
HPLC Conditions (Shimadzu HPLC)				
Column (Column temp = 45°C)	Phenomenex Gemini 3 µm C18 110Å, 50 X 2 mm			
Mobile Phase Composition	A = 20 mM Ammonium Acetate in Water B = Methanol			
Gradient Program	**Time**	**%A**	**%B**	**Flow Rate - mL/min**
	0	90	10	0.60
	0.1	45	55	0.60
	4.5	1	99	0.60
	4.95	1	99	0.60
	5	90	10	0.60
	Maximum pressure limit = 5,000 psi			

Table 4 - Recommended Instrument Operating Conditions	
HPLC Conditions (Shimadzu HPLC)	
Injection Size	2 µL (fixed amount throughout the sequence). If non-concentrated extract then use 20 uL.
Run Time	~6.6 minutes
Mass Spectrometer Interface Settings (SCIEX 5500)	
MS Interface Mode	ESI Negative Ion. Minimum of 10 scans/peak.
Ion Spray Voltage (kV)	4.5
Entrance Potential (V)	5
Declustering Potential (V)	25
Desolvation Temp	600ºC
Curtain Gas	35 psi
Collision Gas	8 psi

Table 5 - Recommended Instrument Operating Conditions

Mass Spectrometer Scan Settings (SCIEX 5500)

Compound	Comments	Reaction (MRM)	Dwell (sec)	Ent. Pot. (V)	Col. Energy (V)	Declu. Pot. (V)	Cell Exit Pot. (V)	Typ RT (Min)
PFBA	Native analyte	212.9 > 169	0.011	-5	-12	-25	-31	1.74
13C4-PFBA	IDA	217 > 172	0.011	-5	-12	-25	-31	1.74
PFBS	Native analyte	298.9 > 80	0.011	-6	-58	-55	-37	1.76
PFBS_2	Native analyte	298.9 > 99	0.011	-5	-40	-55	-12	1.76
13C3-PFBS	IDA	301.9 > 83	0.011	-5	-40	-55	-12	1.76
PFPeA	Native analyte	262.9 > 219	0.011	-7	-12	-20	-34	1.99
13C5-PFPeA	IDA	267.9 > 223	0.011	-7	-12	-20	-35	1.99
4:2 FTS	Native analyte	327 > 307	0.011	-7	-32	-50	-10	2.06
M2-4:2FTS	Reverse Surrogate	329 > 81	0.011	-7	-32	-50	-10	2.06
PFHxA	Native analyte	313 > 269	0.011	-5	-12	-25	-37	2.25
PFHxA_2	Native analyte	313 > 119	0.011	-5	-12	-25	-37	2.25
13C2-PFHxA	IDA	315 > 270	0.011	-5	-12	-25	-38	2.25
PFHpA	Native analyte	363 > 319	0.011	-6	-12	-25	-41	2.57
PFHpA_2	Native analyte	363 > 169	0.011	-6	-12	-25	-41	2.57
13C4-PFHpA	IDA	367 > 322	0.011	-6	-12	-25	-41	2.57
PFPeS	Native analyte	349 > 80	0.011	-9	-66	-57	-40	2.15
PFPeS_2	Native analyte	349 > 99	0.011	-9	-40	-57	-12	2.15
PFHxS	Native analyte	399 > 80	0.011	-12	-74	-60	-43	2.59
PFHxS_2	Native analyte	399 > 99	0.011	-12	-74	-60	-43	2.59
18O2-PFHxS	IDA	403 > 84	0.011	-12	-74	-60	-43	2.59
6:2 FTS	Native analyte	427 > 407	0.011	-7	-32	-50	-10	2.91
M2-6:2FTS	IDA	429 > 81	0.011	-7	-32	-50	-10	2.91
PFOA	Native analyte	413 > 369	0.011	-6	-14	-25	-44	2.93
PFOA_2	Native analyte	413 > 169	0.011	-5	-22	-25	-12	2.93
13C4-PFOA	IDA	417 > 372	0.011	-6	-14	-25	-44	2.93

Table 5 - Recommended Instrument Operating Conditions								
Mass Spectrometer Scan Settings (SCIEX 5500)								
Compound	Comments	Reaction (MRM)	Dwell (sec)	Ent. Pot. (V)	Col. Energy (V)	Declu. Pot. (V)	Cell Exit Pot. (V)	Typ RT (Min)
13C2-PFOA	IS	415 > 370	0.011	-6	-14	-25	-44	2.93
PFHpS	Native analyte	449 > 80	0.011	-11	-88	-65	-46	2.94
PFHpS_2	Native analyte	449 > 99	0.011	-11	-88	-65	-46	2.94
PFNA	Native analyte	463 > 419	0.011	-6	-14	-25	-47	3.29
PFNA_2	Native analyte	463 > 169	0.011	-6	-14	-25	-47	3.29
13C5-PFNA	IDA	468 > 423	0.011	-6	-14	-25	-48	3.29
PFOS	Native analyte	499 > 80	0.011	-9	-108	-65	-50	3.29
PFOS_2	Native analyte	499 > 99	0.011	-5	-58	-65	-12	3.29
PFNS	Native analyte	549 > 80	0.011	-10	-113	-75	-52	3.40
PFNS_2	Native analyte	549 > 99	0.011	-8	-71	-75	-12	3.40
13C4-PFOS	IDA	503 > 80	0.011	-9	-108	-65	-50	3.29
PFDA	Native analyte	513 > 469	0.011	-6	-16	-25	-51	3.65
PFDA_2	Native analyte	513 > 169	0.011	-6	-16	-25	-51	3.65
13C2-PFDA	IDA	515 > 470	0.011	-6	-16	-25	-51	3.65
8:2 FTS	Native analyte	527 > 507	0.011	-7	-40	-50	-15	3.65
M2-8:2FTS	IDA	529 > 81	0.011	-7	-40	-50	-15	3.65
PFOSA	Native analyte	498 > 78	0.011	-8	-85	-60	-50	3.7
13C8-PFOSA	IDA	506 > 78	0.011	-8	-85	-60	-50	3.7
N-MeFOSAA	Native analyte	570 > 419	0.011	-7	-36	-40	-15	3.82
d3-MeFOSAA	IDA	573 > 419	0.011	-7	-36	-40	-15	3.82
PFDS	Native analyte	599 > 80	0.011	-11	-118	-85	-54	3.96
PFDS_2	Native analyte	599 > 99	0.011	-11	-118	-85	-54	3.96
PFUdA	Native analyte	563 > 519	0.011	-7	-18	-25	-54	3.97
PFUdA_2	Native analyte	563 > 169	0.011	-7	-18	-25	-54	3.97
13C2-PFUdA	IDA	565 > 520	0.011	-7	-18	-25	-54	3.97
N-EtFOSAA	Native analyte	584 > 419	0.011	-7	-36	-50	-15	3.99
d5-EtFOSAA	IDA	589 > 419	0.011	-7	-36	-50	-15	3.99
PFDoA	Native analyte	613 > 569	0.011	-5	-18	-25	-54	4.3
PFDoA_2	Native analyte	613 > 169	0.011	-5	-18	-25	-54	4.3
13C2-PFDoA	IDA	615 > 570	0.011	-5	-18	-25	-54	4.3
PFTrDA	Native analyte	663 > 619	0.011	-7	-20	-25	-54	4.56
PFTrDA_2	Native analyte	663 > 169	0.011	-7	-20	-25	-54	4.56
PFTeDA	Native analyte	713 > 169	0.011	-2	-22	-25	-10	4.79
PFTeDA_2	Native analyte	713 > 219	0.011	-7	-36	-25	-30	4.79
13C2-PFTeDA	IDA	715 > 670	0.011	-2	-22	-25	-10	4.79
PFHxDA	Native analyte	813 > 769	0.011	-7	-24	-25	-54	5.25
PFHxDA_2	Native analyte	813 > 169	0.011	-7	-24	-25	-54	5.25
13C2-PFHxDA	IDA	815 > 770	0.011	-7	-24	-25	-54	5.25
PFODA	Native analyte	913 > 869	0.011	-7	-26	-25	-54	5.55
PFODA_2	Native analyte	913 > 169	0.011	-7	-26	-25	-54	5.55

Table 6 - Recommended Instrument Operating Conditions Mass Spectrometer Scan Settings (SCIEX 5500) for Fluorinated Replacement Chemicals								
Compound	Comments	Reaction (MRM)	Dwell (sec)	Ent. Pot. (V)	Col. Energy (V)	Declu. Pot. (V)	Cell Exit Pot. (V)	Typ RT (Min)
HFPO-DA	Native analyte	329.1 > 285	0.011	-10	-6	-48	-17	2.06
13C3-HFPO-DA	IDA	332.1 > 287	0.011	-10	-10	-40	-17	2.06
9Cl-PF3ONS (F53B major)	Native analyte	531 > 351	0.011	-10	-30	-120	-17	3.23
11Cl-PF3OUdS (F53B minor)	Native analyte	631 > 451	0.011	-10	-40	-160	-17	3.84
Adona	Native analyte	377 > 251	0.011	-10	-16	-55	-17	2.33
Adona_2	Native analyte	377 > 85	0.011	-10	-35	-55	-17	2.33

Table 7 - Retention Times & Quantitation (SCIEX 5500)				
Native Compounds	**Typical Native RT (minutes)**	**IS analog**	**Typical IDA RT (minutes)**	**Quantitation Method**
PFBA	1.54	13C4-PFBA	1.54	Isotope Dilution
PFPeA	1.56	13C5-PFPeA	1.56	Isotope Dilution
PFBS	1.78	13C3-PFBS	1.78	Isotope Dilution
PFHxA	2.03	13C2-PFHxA	2.03	Isotope Dilution
PFPeS	2.06	13C3-PFBS	1.78	Isotope Dilution
PFHpA	2.36	13C4-PFHpA	2.36	Isotope Dilution
PFHxS	2.37	18O2-PFHxS	2.37	Isotope Dilution
PFOA	2.71	13C4-PFOA	2.71	Isotope Dilution
PFHpS	2.72	13C4-PFOS	3.09	Isotope Dilution
PFNA	3.09	13C5-PFNA	3.09	Isotope Dilution
PFOS	3.09	13C4-PFOS	3.09	Isotope Dilution
PFNS	3.40	13C4-PFOS	3.09	Isotope Dilution
PFDA	3.45	13C2-PFDA	3.45	Isotope Dilution
FOSA	3.43	13C8-FOSA	3.43	Isotope Dilution
PFDS	3.77	13C4-PFOS	3.09	Isotope Dilution
PFUdA	3.78	13C2-PFUdA	3.78	Isotope Dilution
PFDoA	4.07	13C2-PFDoA	4.07	Isotope Dilution
PFTrDA	4.34	13C2-PFDoA	4.07	Isotope Dilution
PFTeDA	4.58	13C2-PFTeDA	4.58	Isotope Dilution
PFHxDA	4.99	13C2-PFHxDA	4.99	Isotope Dilution
PFODA	5.34	13C2-PFHxDA	4.99	Isotope Dilution
EtFOSAA	3.78	d5-EtFOSAA	3.78	Isotope Dilution
MeFOSAA	3.61	d3-MeFOSAA	3.60	Isotope Dilution
4:2 FTS	1.98	13C3-PFBS	1.78	Isotope Dilution
6:2FTS	2.69	M2-6:2FTS	2.69	Isotope Dilution
8:2FTS	3.44	M2-8:2FTS	3.44	Isotope Dilution

Table 7 - Retention Times & Quantitation (SCIEX 5500)				
Native Compounds	**Typical Native RT (minutes)**	**IS analog**	**Typical IDA RT (minutes)**	**Quantitation Method**
HFPO-DA	2.06	13C3-HFPO-DA	2.06	Isotope Dilution
9Cl-PF3ONS (F53B major)	3.23	13C4-PFOS	3.09	Isotope Dilution
11Cl-PF3OUdS (F53B minor)	3.84	13C4-PFOS	3.09	Isotope Dilution
Adona	2.33	13C4-PFOS	3.09	Isotope Dilution

11.18.1. Post Spike Sample Analysis for AFFF samples

11.18.1.1. This section only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of <LOQ (RL) for any analyte.

11.18.1.2. Spike aliquots of the sample at the final dilution reported for the sample with all analytes that have reported of <LOQ in the final dilution. The spike must be at the LOQ concentration to be reported with the sample (the < LOQ value).

11.18.1.3. When analyte concentrations are calculated as <LOQ, the spike must recover within 70-130% of its true value.

11.18.1.4. It the recovery does not meet this criteria, the sample, sample duplicate and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria is met.

11.18.2. Tune and calibrate the instrument as described in Section 10.

11.18.3. A typical run sequence is as follows:

- Rinse Blank (RB, not linked to anything)
- Start ICAL with CCVL but called IC in TALS (starts the 12 hour clock or time 0:00)
- Rest of ICAL
- ICB: link to midpoint of ICAL and samples
- ICV: link to midpoint of ICAL and samples (If ICAL good)
- CCB: link to midpoint of ICAL and samples
- PFOA RT marker (as needed)
- Rinse Blank (RB, not linked to anything)
- 10 samples: link to midpoint of ICAL
- CCV: link to midpoint of ICAL
- 10 more samples: link to midpoint of ICAL

- CCV: link to midpoint of ICAL
- Etc.
- CCVL (within 12 hours from CCVL in ICAL, can be the ending CCV and starts 12 hours all over again): if this occurs link to the midpoint of the ICAL/toggle it as opening/closing CCV.
- CCV: link to midpoint of ICAL
- 10 samples: link to midpoint of ICAL
- CCV: link to midpoint of ICAL
- If no ICAL run that day
- CCB: link to CCVIS
- CCVL (starts 12 hour clock): link to CCVIS
- CCVIS: link to midpoint of ICAL
- 10 samples: link to CCVIS
- CCV: link to CCVIS
- 10 samples: link to CCVIS
- CCV: link to CCVIS
- Etc.
- If going over 12 hours in the sequence : CCVL (within 12 hours from CCVL at item 2 above, can be the ending CCV and starts 12 hours all over again): if this occurs link to the CCVIS /toggle as opening and closing CCV.
- CCV: link to CCVIS
- 10 samples: link to CCVIS
- CCV: link to CCVIS

12. CALCULATIONS

12.1. If the concentration of the analyte ions exceeds the working range as defined by the calibration standards, then the sample must be diluted and reanalyzed. It may be necessary to dilute samples due to matrix.

12.2. Qualitative Identification

12.2.1. The retention times of PFAS with labeled standards should be the same as that of the labeled IDA's to within 0.05 min. For PFAS with no labeled standards, the RT must be within ± 0.3 minutes of the ICV and CCV standards. *Note: The IDA RT and native RT may be offset by 0.02 to 0.04 minutes.*

12.3. The ICAL established in Section 10 is used to calculate concentrations for the extracts.

12.4. Extract concentrations are calculated as below. The first equation applies to the linear fit, the second to the quadratic line fit.

Equation 3

$$\text{Concentration, ng/mL} = \frac{y - c}{b}$$

Equation 4

$$\text{Concentration, ng/mL} = \frac{-b + \sqrt{b^2 - 4a(c - y)}}{2a}$$

Where:

y = $\frac{\text{Area (analyte)}}{\text{Area (IS)}} \times \text{Concentration (IS)}$
x = concentration
a = curvature
b = slope
c = intercept

12.5. Water Sample Result Calculation:

Equation 5

$$\text{Concentration, ng/L} = \frac{C_{ex} V_t}{V_o}$$

Where:

C_{ex} = Concentration measured in sample extract (ng/mL)
V_t = Volume of total extract (mL)
V_o = Volume of water extracted (L)

12.6. Soil Sample Result Calculation:

Equation 6

$$\text{Concentration, } ng/g = \frac{C_{ex} V_t}{W_s D}$$

Where ng/g = µg/kg and:

C_{ex} = Concentration measured in sample extract (ng/mL)
V_t = Volume of total extract (mL)
W_s = Weight of sample extracted (g)
D = Fraction of dry solids, which is calculated as follows:

$\frac{100 - \%\text{ moisture in sample}}{100}$ (for dry weight result)

12.7. IDA Recovery Calculation:

Equation 7

$$\%\,\mathrm{Recovery} = \frac{A_t Q_{is}}{A_{is} Q_t RRF_{IDA}} X 100$$

Where ng/g = µg/kg and:

RF_{IDA}	=	Response Factor for IDA compound
A_t	=	Area response for IDA compound
A_{IS}	=	Area Response for IS compound
Q_{IS}	=	Amount of IS added
Q_t	=	Amount of IDA added

12.8. Raw data, calibration summaries, QC data, and sample results are reviewed by the analyst. These must also be reviewed thoroughly by a second qualified person. See the Data Review Policy (WS-PQA-0012). These reviews are documented on the Data Review Checklist.

13. METHOD PERFORMANCE

13.1. The group/team leader has the responsibility to ensure that this procedure is performed by an associate who has been properly trained in its use and has the required expertise.

13.2. Method Detection Limit

The laboratory must generate a valid method detection limit for each analyte of interest. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in SOP WS-QA-0006 and policy WS-PQA-003. MDLs are available in the Quality Assurance Department.

13.3. Initial Demonstration of Capability (IDOC)

Each analyst performing this procedure must successfully analyze four LCS QC samples using current laboratory LCS control limits. IDOCs are approved by the Quality Assurance Manager and the Technical Director. IDOC records are maintained by the QA staff in the central training files.

13.4. The laboratory must generate a valid method detection limit for each analyte of interest. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in WS-QA-0006 and policy WS-PQA-003.

14. POLLUTION PREVENTION

14.1. All waste will be disposed of in accordance with Federal, State and Local regulations.

14.2. Solid phase extraction used for water samples greatly reduces the amount of solvent used compared to liquid-liquid extraction.

14.3. Standards and reagents are purchased and prepared in volumes consistent with laboratory use to minimize the volume of expired standards and reagents requiring disposal.

14.4. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in Section 13 of the Corporate Safety Manual for "Waste Management and Pollution Prevention."

14.5. Do not allow waste solvent to vent into the hoods. All solvent waste is stored in capped containers unless waste is being transferred.

14.6. Transfer waste solvent from collection cups (tri-pour and similar containers) to jugs and/or carboys as quickly as possible to minimize evaporation.

15. WASTE MANAGEMENT

The following waste streams are produced when this method is carried out:

15.1. Assorted test tubes, autovials, syringes, filter discs and cartridges. Dump the solid waste into a yellow contaminated lab trash bucket. When the bucket is full or after no more than one year, tie the plastic bag liner shut and put the lab trash into the hazardous waste – landfill steel collection drum in the H3 closet. When the drum is full or after no more than 75 days, move it to the waste collection area for shipment.

15.2. Extracted soil samples, used sodium sulfate, paper funnel filters, glass wool, thimbles, and extracted solids contaminated with solvents. Dump these materials into an orange contaminated lab trash bucket. When the bucket is full or after no more than one year, tie the plastic bag liner shut and put the lab trash into the incineration steel collection drum in the H3 closet. When the drum is full or after no more than 75 days, move it to the waste collection area for shipment.

15.3. Waste Methanol. Collect the waste solvents in tripours during use. Empty the tripours into a 1-liter to 4-liter carboy at the fume hood. When the carboy is full, or at the end of your shift, whichever comes first, empty the carboy into the steel flammable solvent drum in the H3 closet. When full to no less than six inches of the top, or after no more than 75 days, move the steel flammable solvent drum to the waste collection area for shipment.

15.4. Mixed water/methanol waste from soil extraction. Collect the waste in the HPLC waste carboy. When full, or after no more than one year, dump into the blue plastic HPLC collection drum in the H3 closet. When the drum is full, to no less than six inches of the top, or after no more than 75 days, move it to the waste collection area for shipment.

15.5. Aqueous acidic waste from the LCMS instrument contaminated with methanol. This is collected in a 1-gallon carboy at the instrument. When the carboy is full, or after no more than one year, it is emptied into the blue plastic HPLC collection drum in the H3 closet. When the drum is full to between two and six inches of the top, or after no more than 75 days, move it to the waste collection area for shipment.

15.6. Autovials contaminated with methanol. As the autovials are removed from the instrument after analysis, they are collected in open containers at the instrument. After all autovials are removed, the open container must be dumped into a closed satellite collection container in a fume hood, as the punctured septa in the autovial can allow methanol and other contaminants to evaporate into the atmosphere. The satellite collection containers are transferred to the waste disposal area when full or after no more than one year, where they are disposed through the vial eater.

16. REFERENCES

16.1. Cheryl Moody, Wai Chi Kwan, Johnathan W. Martin, Derek C. G. Muir, Scott A. Mabury, “Determination of Perfluorinated Surfactants in Surface Water Samples by Two Independent Analytical Techniques: Liquid Chromatography/Tandem Mass Spectrometry and 19FNMR,” Analytical Chemistry 2001, 73, 2200-2206.

16.2. John Giesy et al., “Accumulation of Perfluorooctane Sulfonate in Marine Mammals”, Environmental Science & Technology, 2001 Vol. 35, No. 8, pages 1593-1598.

16.3. U.S. EPA, “Residue Chemistry Test Guidelines, OPPTS 860.1340, Residue Analytical Method”, EPA 712-C-95-174, August 1995.

16.4. STL Denver White Paper DEN-W-LC-002, “Method Validation Study for Analysis of Ammonium Perfluorooctanate in Soil Matrices by High Performance Liquid Chromatography/Mass Spectrometry (HPLC/MS/MS)”, Mark Dymerski, September 5, 2003.

16.5. STL Denver White Paper DEN-W-LC-003, “Addendum A to Method Validation Study for Analysis of Ammonium Perfluorooctanate in Soil Matrices by High Performance Liquid Chromatography/Mass Spectrometry (HPLC/MS/MS)”, Mark Dymerski, August 6, 2003.

16.6. STL Denver White Paper DEN-W-LC-004, “Method Validation Study for Analysis of Perfluorooctanoic Acid in Waters by High Performance Liquid Chromatography/Tandem Mass Spectrometry (HPLC/MS/MS)”, Mark Dymerski, January 26, 2005.

16.7. Waters application note; “Acquity UPLC System for Quantifying Trace Levels of Perfluorinated Compounds with an Acquity PFC Analysis Kit”, Peter J. Lee, Evan T.

Bernier, Gordon T. Fujimoto, Jeremy Shia, Michael S. Young, and Alice J. Di Gloia, Waters Corporation, Milford, MA. USA.

16.8. US EPA, "Method 537 - Determination of Selected Perfluorinated alkyl acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometery (LC/MS/MS)", Version 1.1, September 2009, J.A. Shoemaker, P.E. Grimmett, B.K. Boutin, EPA Document #: EPA/600/R-08/092

16.9. Erika F. Houtz and David L. Sedlak, "Oxidative Conversion as a Means of Detecting Precursors to Perfluoroalkyl Acids in Urban Runoff," Environmental Science and Technology 46, no. 17 (2012): 9342-49.

17. METHOD MODIFICATIONS

17.1. Modifications from Method 537 are detailed below:

17.1.1. Water sample containers are not preserved with Trizma.

17.1.2. The method has been modified to address soil/solid matrices. The extraction holding time is set at 14 days.

17.1.3. The analyte list has been expanded. The number of labeled analytes has been expanded as well to improve quantitation.

17.1.4. The reporting limits differ as they are all set at one consistent value.

17.1.5. Calibration levels differ from the referenced method.

17.1.6. More labeled analytes are fortified into the samples prior to the extraction process. Most target analytes are quantitated against a labeled analyte.

17.1.7. There is no symmetry requirement.

17.1.8. Calibration, both initial and continuing, has different acceptance criteria due to the longer list of analytes, and the use of isotope dilution quantitation.

17.1.9. The eluents and HPLC configuration differs. As a result the final extract is in 80:20 methanol:water.

17.1.10. The LCS and MS/MSD are spiked at one concentration and do not rotate between a low to high levels.

17.1.11. Samples are not checked for residual chlorine or pH.

17.1.12. A different SPE cartridge (Waters OASIS WAX) is used for the extraction

process. As a result solvents and elution procedures are different.

18. ATTACHMENTS

18.1. Attachment 1 - Analysis of Perfluorinated Compounds (PFAS) in Water via In Line Solid Phase Extraction (SPE).

19. REVISION HISTORY

Revisions to Attachment 1 are documented in the attachment.

Revisions prior to 05/01/2017 have been removed and are available in previous versions of this SOP.

19.1. WS-LC-0025, Revision 3.0, Effective 04/13/2018

19.1.1. Section 1.1 updated table with PFPeS and PFNS analytes.

19.1.2. Added Section 2.2, which details the analytes that can be covered by the method under special request.

19.1.3. Added Section 3.13, “AFFF: Aqueous Film Forming Foam”.

19.1.4. Section 6.19 added, “Create all eluents in Reagent module, label eluent containers with TALS label and place 2nd label into maintenance log when put into use” to table.

19.1.5. Section 7.1.2 added, “Prepared by weighing 1.509g of ammonium acetate and dissolving in 1L of water. The resultant solution is filtered through a 0.22um filter before use. This solution has volatile components, thus it should be replaced every 7 days or sooner.”

19.1.6. Section 7.1.3 added, “Prepared by diluting 12mL of ammonium hydroxide into 4L of methanol.”

19.1.7. Section 7.1.8 added, “Prepared by weighing 16g of potassium hydroxide and dissolving in 4L of methanol.”

19.1.8. Section 7.1.11 added, “Prepared by diluting 400mL of 1N NaOH into 3.6L of water for a total volume of 4L.”

19.1.9. Section 7.4 updated table with PFPeS and PFNS analytes.

19.1.10. Section 7.4, added table to detail ICAL for Fluorinated Replacement Compounds.

19.1.11. Added Section 8.1.1, “Water samples collected from a known chlorinated

source should be preserved with Trizma."

19.1.12. Added Section 9.9.3, "If the IS does not meet criteria, re-analyze the extract. If the IS meets criteria in the second analysis, report that analysis. If the IS does not meet criteria in the second analysis, report the first analysis with narration."

19.1.13. Added Section 11.14.6, "Add 2g of potassium persulfate and 1.9 mL of 10N NaOH to each "Post" sample container."

19.1.14. Removed Section 11.14.8, "Add 2g of potassium persulfate and 1.9 mL of 10N NaOH to each "Post" sample container."

19.1.15. Added Section 11.14.9, "Cap each "Post" sample container, invert 2-3 times prior to placing container into water bath."

19.1.16. Added Section 11.5 and associated subsections, which detail the "TOPS (Total Oxidizable Precursor) Assay for Soil Sample".

19.1.17. Section 11.8 updated Table labeling, added PFPeS and PFNS analytes throughout Tables where applicable, and updated Table 7 to reflect current retention times and quantitation.

19.1.18. Section 11.8 added Table 6, "Recommended Instrument Operating Conditions Mass Spectrometer Scan Settings (SCIEX 5500) for Fluorinated Replacement Chemicals"

19.1.19. Section 11.18.3 removed outdated run sequence and replaced with current run sequence.

19.1.20. Editorial changes.

19.2. WS-LC-0025, Revision 2.9, Effective 11/22/2017

19.2.1. Section 1.2, table updated to reflect ranges after removing MeFOSA and EtFOSA from the SOP in the previous revision.

19.2.2. Section 9.3.6, last sentence changed to read, "Reprepare and reanalyze all field and QC samples associated with the contaminated method blank."

19.2.3. Section 9.7, first sentence changed to read, "Initial calibration verification (ICV) – A second source standard is analyzed with the initial calibration curve.

19.2.4. Section 1.3.1 revised to read, "Once the optimal mass assignments (within

±0.5 amu of true) are made immediately following the initial tune, the lowest level standard from the initial calibration curve is assessed to ensure that a signal to noise ratio greater than 10 to 1 (S/N > 10:1) is achieved for each PFAS analyte. The first level standard from the initial calibration curve is used to evaluate the tune stability on an ongoing basis. The instrument mass windows are set initially at ± 0.5 amu of the true value; therefore, continued detection of the analyte transition with S/N > 10:1 serves as verification that the assigned mass remains within ± 0.5 amu of the true value, which meets the DoD/DOE QSM tune criterion. For QSM work, the instrument sensitivity check (section 10.12.4) is also evaluated to ensure that the signal to noise criteria is met."

19.2.5. Editorial changes.

19.3. WS-LC-0025, Revision 2.8, Effective 11/06/2017

19.3.1. Revised Section 4.5 to "Both branched and linear PFAS isomers can potentially be found in the environment. Linear and branched isomers are known to exist for PFOS, PFOA, PFHxS, PFBS, EtFOSAA, and MeFOSAA based upon the literature. If multiple isomers are present for one of these PFAS they might be adjacent peaks that completely resolved or not, but usually with a deflection point resolved during peak integration. The later of these peaks match the retention time of its labeled linear analog. In general, earlier peaks are the branched isomers and are not the result of peak splitting.

At this time only PFOS, PFOA and PFHxS are commercially available as technical mixtures. These reference standards of the technical mixtures for these specific PFAS are used to ensure that all appropriate peaks are included during peak integration."

19.3.2. Sections 4.8 and 7.2.1.1, corrected the in-sample contributions to 0.30 ng/L and 0.015 ug/kg.

19.3.3. Removed Section 7.1.14, "Methanol-Water, 78:22 vol./vol., prepared by mixing 780 mL methanol and 220 mL reagent water. Stored in polypropylene bottle and sealed with polypropylene screw cap." Reagent was added incorrectly.

19.3.4. Section 7.2.4, corrected the factor to 0.956 from 1.046.

19.3.5. Added Section 7.4.1, "A technical (qualitative) grade PFOA standard which contains both linear and branched isomers is used as a retention time (RT) marker. This is used to integrate the total response for both linear and branched isomers of PFOA in environmental samples while relying on the

initial calibration with the linear isomer quantitative standard This technical (qualitative) grade PFOA standard is analyzed initially, after an initial calibration when a new column is installed or when significant changes are made to the HPLC parameters."

19.3.6. Section 9.7, added "Rerun the initial calibration" as the last bullet item.

19.3.7. Added Section 10.3.1, "The first level standard from the initial calibration curve is used to evaluate the tune criteria. The instrument mass windows are set at ±0.5 amu; therefore, detection of the analyte serves as verification that the assigned mass is within ±0.5 amu of the true value, which meets the DoD/DOE QSM tune criterion.

19.3.8. Section 10.10.1, appended "containing both IDA and IS" to the end of the paragraph.

19.3.9. Sections 11.6.3 and 11.12.2.3, changed "78:22 methanol:water" to "methanol".

19.3.10. Sections 1.1 and 7.4, removed EtFOSA and MeFOSA from tables due to low volume of requests for those analytes.

19.3.11. Removed Section 2.2.1, "Optional cleanups may include sample freezing and/or cleanup by SPE cartridge, unless EtFOSA and MeFOSA are requested."

19.3.12. Removed EtFOSA/MeFOSA specific comments in various sections throughout the document.

19.3.13. Section 7.4 Note added, "The concentration of the calibration solutions for non-concentrated extracts is 1/20th the levels indicated above."

19.3.14. Section 7.9, changed 1000 ng/mL to 250 ng/mL and replaced final sentence with "The internal standard solution used for the non-concentrated extracts is at a concentration of 50 ng/mL."

19.3.15. Removed Section 11.2.8, "If EtFOSA and/or MeFOSA are requested, add 100uL of IS and then adjust the final volume (FV) of these aliquots to 5.0 mL with MeOH. QC samples, LCS, MS, and MSD will require concentration via nitrogen to adjust the FV to 5.0 mL. Vortex each sample. Then, transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution."

19.3.16. Added Section 11.5.4, "Proceed to Section 11.15.2 (Graphitized Carbon

Cleanup) as needed. This is required for all DoD/DOE extracts."

19.3.17. Added Section 11.7.1.1, "Seal the test tube tightly. Invert container several times and then vortex. Allow extract to settle for 10 minutes prior to moving to the next step."

19.3.18. Inserted Section 11.8.1.1, "Projects performed under the auspices of the DoD/DOE must have the entire sample homogenized prior to subsampling in accordance with QSM 5.1 criteria."

19.3.19. Section 11.11.4, added "(Graphitized Carbon Cleanup) as needed. This is required for all DoD/DOE extracts."

19.3.20. Section 11.14.6, added "Spike all "Pre" and "Post" samples with 25uL of the reverse surrogate solution (Section 7.8)."

19.3.21. Section 11.15.2, revised to read, "Cleanup with graphitized carbon will be applied to all samples as needed but is required for all DoD/DOE extracts."

19.3.22. Added Section 11.15.2.5, "Proceed to Section 11.6, 11.7, or 11.12 as applicable."

19.3.23. Removed Sections 11.15.3 through 11.15.6.

19.3.24. Added Section 11.16, "AFFF Sample Preparation".

19.3.25. Section 11.17, removed EtFOSA, MeFOSA, d5-EtFOSA, and d3MeFOSA from all tables.

19.3.26. Section 11.17, changed masses for M2-4:2FTS, M2-6:2FTS, and M2-8:2FTS. Initially assigned daughter masses were bleeding through from the native analog.

19.3.27. Section 11.17, all tables on MS Interface Mode Line, added "Minimum of 10 scans/peak."

19.3.28. Added Section 11.17.1, "Post Spike Sample Analysis for AFFF Samples".

19.3.29. Added Section 11.8.4.1 "Spike non-concentrated samples at 0.5 mL of LCS/Matrix Spike Solution."

19.3.30. Added Section 11.8.5.1, "Spike non-concentrated samples at 0.5 mL of IDA PFC Solution."

19.3.31. Editorial changes.

19.4. WS-LC-0025, Revision 2.7, Effective 09/20/2017

19.4.1. Section 1.1 table, added 1H,1H,2H,2H-perfluorohexane sulfonate *(4:2)*.

19.4.2. Section 1.1, removed "Sample results for PFOA may also be reported as APFO, at the request of the client. (See Section 12.7)."

19.4.3. Section 1.2 and 11.8.2, updated tissue extracted mass and RL.

19.4.4. Section 2.5, removed "and assumes a proportional relationship between the initial calibration and the analyte in the extract. The ratio of the peak response to mass or concentration injected is used to prepare a calibration curve."

19.4.5. Added Section 6.6, "Extract concentrator or nitrogen manifold with water bath heating to 50-55°C".

19.4.6. Added Section 7.1.14, "Methanol-Water, 78:22 vol./vol., prepared by mixing 780 mL methanol and 220 mL reagent water. Stored in polypropylene bottle and sealed with polypropylene screw cap."

19.4.7. Section 7.2.1.1, revised "roughly 0.15 pg/L" to "roughly 0.15 ng/L".

19.4.8. Section 7.4 table, added:

4:2 FTS	0.5	1.0	2.0	20	50	200	400

19.4.9. Section 7.4 table, revised Labeled Isotope Dilution Analytes (IDA) Section.

19.4.10. Section 7.4 table, added:

Internal Standard (IS)							
13C2-PFOA	50	50	50	50	50	50	50

19.4.11. Section 7.4, removed "FOSAA may be added to the mix and are added at the same concentration as FOSA."

19.4.12. Added Section 7.9, "Internal Standard Solution, 1000 ng/mL. The internal standard solution is prepared by diluting 13C2-PFOA to produce a solution containing this compound at a concentration of 1000 ng/mL in methanol. This is added to all extracts prior to analysis. Non-concentrated extracts are fortified with a 5X dilution of this solution."

19.4.13. Section 8.1, changed "250 mL" to "8 oz."

19.4.14. Added Sections 9.3.6, 9.8.2.3, 10.10.4, 10.8.2.5, 10.11.3, and 10.12.4 to address DOD QSM 5.1 Table B-15 criteria.

19.4.15. Added Section 9.9, “Internal Standard.”

19.4.16. Updated all tables to indicate target analyte quantitation via isotope dilution. Internal standard quantitation is only used to quantitate the IDA recoveries.

19.4.17. Added Section 10.8.2.4, 10.12.2, and 10.12.2.1 to incorporate IS criteria into calibrations.

19.4.18. Section 11.2.1, “Evaluate if the sample can be decanted or centrifuged; if not, contact the client for guidance. Filtering the sample can lead to a low bias.”

19.4.19. Added Section 11.2.3.1, “Alternatively, weigh the sample container prior to extraction and then weigh the sample container after extraction to determine the initial volume.”

19.4.20. Added Section 11.5.3, “Note: If the extracts will not be concentrated elute extract with a total of 8 mL of 0.3% NH_4OH/methanol.”

19.4.21. Added Section 11.6.2.3, “Add 300 uL of the 78:22 methanol:water solution and mix the contents well using a vortex mixer.”

19.4.22. Added Section 11.6.2.4, “Add 100 uL of Internal Standard (IS) solution to each extract and vortex to mix.”

19.4.23. Added Section 11.7, “Final volume for non-concentrated extract”.

19.4.24. Revised Section 11.11, “SPE Elution of Solid Extracts”.

19.4.25. Revised Section 11.12, “Extract Concentration for Solid Samples”.

19.4.26. Removed Section 12.8, “If results are to be reported as ammonium perfluorooctanoate (APFO), instead of PFOA, apply a multiplier of 1.0406 to the sample results to correct for the molecular weight differences between PFOA and APFO or this adjustment can be made during the preparation of the standards used for calibration. (Use one, not both.)”

19.4.27. Removed Section 13.4 – it was a copy of Section 13.2.

19.4.28. Various revisions to fulfill requirements based on DOD/DOE QSM 5.1.

19.4.29. Editorial changes.

19.5. WS-LC-0025, Revision 2.6, Effective 08/15/2017

19.5.1. Section 7.4, added MPFBS, MPFTeDA, and MPFHxDA to the table.

19.5.2. Section 11.15, added 13C-PFBS to the Recommended Instrument Operating Conditions table for SCIEX 5500.

19.5.3. Section 11.15 Recommended Instrument Operating Conditions table, changed the mass transitions for native PFTeDA from 713 > 669 (quant) and 713 > 169 (qualifier) to 713 > 169 (quant) and 713 > 219 (qualifier).

19.5.4. Editorial changes.

19.6. WS-LC-0025, Revision 2.5, Effective 07/10/2017

19.6.1. Revised Section 11.6.1 to read “Prior to concentrating each sample, add 100 uL of water.”

19.6.2. Revised Section 11.6.2 to read “Concentrate each sample under a gentle stream of nitrogen until the methanol is evaporated and the 100 uL of water remains.

11.6.2.1 This blow down must take a minimum of 3.5 hours.

11.6.2.2 Extracts can not remain in the water bath longer than 5 minutes once concentrated.”

19.6.3. Revised Section 11.6.3 to read “Add 400 uL of methanol to each extract, soak, and vortex to mix well. This will create an extract with a final solvent composition of 80:20 methanol:water.”

19.6.4. Revised Section 11.11.1 to read “Prior to concentrating each sample, add 200 uL of water.”

19.6.5. Revised Section 11.11.2 to read “Concentrate each sample under a gentle stream of nitrogen until the methanol is evaporated and the 200 uL of water remains.”

11.11.2.1 This blow down must take a minimum of 3.5 hours.

11.11.2.2 Extracts can not remain in the water bath longer than 5 minutes once concentrated.”

19.6.6. Revised Section 11.11.3 to read “Add 800 uL of methanol to each extract, soak, and vortex to mix well. This will create an extract with a final solvent composition of 80:20 methanol:water.”

1. SCOPE AND APPLICATION

1.1. This procedure describes the analysis of water samples via in line solid phase extraction (SPE) for the following compounds using liquid chromatography / tandem mass spectrometry (LC/MS/MS) on a SCIEX 5500.

Compound Name	Abbreviation	CAS #
Perfluoroalkylcarboxylic acids (PFCAs)		
Perfluoro-n-heptanoic acid	PFHpA	375-85-9
Perfluoro-n-octanoic acid	PFOA	335-67-1
Perfluoro-n-nonanoic acid	PFNA	375-95-1
Perfluorinated sulfonic acids (PFSAs)		
Perfluoro-1-butanesulfonic acid	PFBS	375-73-5
Perfluoro-1-hexanesulfonic acid	PFHxS	355-46-4
Perfluoro-1-octanesulfonic acid	PFOS	1763-23-1

1.2. The working range of the method is listed below. The linear range can be extended by diluting the extracts.

Matrix	Nominal Sample Size	Reporting Limit	Working Range
Water	1.0 mL	2.0 ng/L	2 to 200 ng/L

2. SUMMARY OF METHOD

2.1. A 1 mL aliquot of sample is diluted to a 40:60 methanol:water extract and analyzed by LC/MS/MS. PFAS are separated from other components on a C18 column with a solvent gradient program using 20mM ammonium acetate/water and methanol.

3. DEFINITIONS

Refer to Section 3 of the main body of this SOP for a summary of definitions.

4. INTERFERENCES

Refer to Section 4 of the main body of this SOP for interferences.

5. SAFETY

Refer to Section 5 of the main body of this SOP for safety information.

6. EQUIPMENT AND SUPPLIES

Refer to Section 6 of the main body of this SOP for supplies, other than those listed below specific to the in line SPE analysis.

6.1. 2 mL auto sampler vials, clear glass, Thermo Scientific Nation surestop vial, part no. C5000-1, or equivalent**.**

6.2. Vial caps, Thermo Scientific National AVCS blue cap, pre slit TEF/STL septa, part no. C5000-55B or equivalent.

6.3. Eppendorf 1000 uL epTIPS, part no. 022491954 or equivalent.

6.4. Eppendorf 200 uL epTIPS, part no. 022491938 or equivalent.

6.5. 50 mL graduated plastic centrifuge tubes, SCP Science DigiTUBES part no. 010-500-263 or equivalent

6.6. 1000 uL Pipette: Eppendorf Research Plus

6.7. 100 uL Pipette: Rainin EDP3-Plus

6.8. 250 mL HDPE bottles with PPE screw caps, ESS part no. 0250-1902-QC or equivalent.

6.9. Analytical columns

6.9.1. Phenomenex Gemini C18 3 um, 3.0 mm x 100 mm, Part No. 00D-4439-Y0, or equivalent.

6.9.2. PFAS Isolator column, Phenomenex Luna C18 5 um, 50 mm x 4.6 mm, part no. 00B-4252-E 0 or equivalent.

6.10. SCIEX 5500 Triple Quad MS. The system utilizes Chrom Peak Review, version 2.1 or equivalent.

6.11. Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent.

7. REAGENTS AND STANDARDS

Refer to Section 7 of the main body of this SOP for reagents and standards, other than those listed below specific to the in line SPE analysis.

7.1. Reagent grade chemicals shall be used in all tests whenever available. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on the Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.1.1. Ammonium acetate, Fisher Optima LCMS grade (20 mM in water), part no. A114-50, or equivalent.

7.1.2. Methanol, Baker HPLC grade, part no. 9093-03.

7.1.3. Water, Nanopure or Millipore or Fisher Optima LCMS grade, part no. W6-4, must be free of interference and target analytes.

7.2. Calibration Standards

The calibration stock solution is prepared by diluting the appropriate amounts of the stock solutions (Section 7.2 of the main body of this SOP) in 40:60 methanol:water. The calibration stock solution is diluted with methanol to produce initial calibration standards. These are the normal calibration levels used. A different range can be used if needed to achieve lower reporting limits or a higher linear range.

7.3. Initial Calibration (ICAL) Levels (ng/L)

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7	CS-8
Perfluoroalkylcarboxylic acids (PFCAs)								
PFHpA	1.0	2.0	5.0	10	20	50	100	200
PFOA	1.0	2.0	5.0	10	20	50	100	200
PFNA	1.0	2.0	5.0	10	20	50	100	200
Perfluorinated sulfonic acids (PFSAs)								
PFBS	1.0	2.0	5.0	10	20	50	100	200
PFHxS	1.0	2.0	5.0	10	20	50	100	200
PFOS	1.0	2.0	5.0	10	20	50	100	200
Labeled Isotope Dilution Analytes (IDA)								
13C4-PFHpA	50	50	50	50	50	50	50	50
13C4-PFOA	50	50	50	50	50	50	50	50
13C5-PFNA	50	50	50	50	50	50	50	50
18O2-PFHxS	50	50	50	50	50	50	50	50
13C4-PFOS	50	50	50	50	50	50	50	50

Note- The above calibration levels are provided only as an example. The actual ICAL level used for each analytical batch will depend upon the LOQ requirements of the program.

7.4. LCS/Matrix PFC Spike Solution, 100 ng/mL.

The PFC spike solution is prepared by diluting all PFAS to produce a solution containing each PFAS at 100 ng/mL in methanol.

7.5. PFC Isotope Dilution Analyte (IDA) Spike Solution, 1 ng/mL.

The PFC-IDA solution is prepared by diluting all labeled PFAS to produce a solution containing each at 1 ng/mL in methanol.

8. SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1. Water samples are collected in pre-cleaned 250 mL HDPE containers. Other containers may also be suitable. Samples are chilled to 0 - 6 °C for shipment to the laboratory.

8.2. Samples are logged in following normal laboratory procedures and are stored under refrigeration at 0 - 6 °C. Water samples must be analyzed within 28 days of collection.

9. QUALITY CONTROL

Refer to Section 9 of the main body of this SOP for Quality Control information.

9.1. If potable water samples from the state of New York (NY) are analyzed via this method the control limits for LCS and IDA for PFOS and PFOA recoveries are 70-130%. If these limits are not met, refer to Section 9 of the main body of this SOP for corrective action.

9.2. If POST (treatment) samples have positive detections, review the associated PRE and MID (treatment) samples for similar detections. Re-preparation and re-analysis may be needed.

9.3. If PFBS is detected in the method blank greater than the RL, evaluate data for impact. PFBS is a known laboratory artifact. Re-preparation and re-analysis may be needed.

10. CALIBRATION

Refer to Section 10 of the main body of the SOP for calibration information.

11. PROCEDURE

Refer to Section 11 of the main body of this SOP for procedures, other than those listed below specific to the in line SPE analysis.

11.1. Water Sample Preparation

11.1.1. Visually inspect samples for the presence of settled and or suspended sediment/particulate. Evaluate if the sample can be decanted or centrifuged; if not, contact the client for guidance. Filtering the sample can lead to a low bias.

If authorized by the client to filter the sample, filter the water sample through a glass fiber filter (Whatman GF/F Cat No 1825 090 or equivalent). Gravity of vacuum can be used to pass the sample through the filter. Prepare a filtration blank with any samples requiring filtration. File an NCM noting the need for filtration.

Warning: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.1.2. Prepare an LCS and method blank by adding 250 mL of HPLC grade water into a 250 mL HDPE bottle.

11.1.3. If requested, find the client assigned sample for MS/MSD.

11.1.4. Spike directly into the sample bottles for the LCS and MS/MSD (if requested) with 0.050 mL (50 uL) of the LCS/Matrix PFC Spike solution (Section 7.4). This will result in a sample concentration of 20 ng/L. Shake well to disperse spike.

11.1.5. Measure 1 mL of each sample using an Eppendorf pipette and pour into a labeled 2.0 mL injection vial. This includes the LCS and method blank samples as well.

11.1.6. Be sure to "prepare" the pipette by collecting two 1 mL aliquots and disposing of them, and then collect the aliquot for testing.

11.1.7. Add 83 uL of surrogate solution (PFC IDA Spike Solution, Section 7.5) into each vial for each sample and QC sample. This will result in an extract concentration of 50 ng/L for the surrogate.

11.1.8. Add 577 uL of methanol to each sample for a final solvent composition of 40:60 methanol:water.

11.1.9. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps can not be used due to detection of low level concentration of PFAS.

11.1.10. Vortex to mix the mixture well.

11.2. Instrument Analysis

11.2.1. Suggested operation conditions are listed in Tables 1A-1C below:

Table 1A - Routine Instrument Operating Conditions

HPLC Conditions (Shimadzu HPLC)					
Column (Column temp = 35°C)	Phenomenex Gemini C18 3 um, 3.0 mm x 100 mm				
Mobile Phase Composition	A = 20 mM Ammonium Acetate in Water B = Methanol				
Gradient Program	**Time (min)**	**%A**	**%B**	**Curve**	**Flow Rate (mL/min)**
	0	90	10	6	0.60
	1	90	10	6	0.60

Table 1A - Routine Instrument Operating Conditions					
HPLC Conditions (Shimadzu HPLC)					
	1.5	35	65	6	0.60
	8	5	95	6	0.60
	8.1	1	99	6	0.60
	12	1	99	6	0.60
	12.5	90	10	6	0.60
	Maximum Pressure limit = 5,000 psi				
Injection Size	950 uL (fixed amount throughout the sequence)				
Run Time	17.1 minutes				
MS Interface Mode	ESI Negative Ion. Minimum of 10 scans/peak.				
Ion Spray Voltage (kV)	4.5				
Entrance Potential (V)	5				
Declustering Potential (V)	25				
Desolvation Temp	550 ºC				
Curtain Gas (nitrogen) Flow	35 psi				
Collision Gas (nitrogen) Flow	8 psi				

Table 1B - Routine Instrument Operating Conditions						
Mass Spectrometer Scan Settings (SCIEX 5500)						
Compound	**Comments**	**Reaction (MRM)**	**Dwell (sec)**	**Ent. Pot. (V)**	**Col. Energy (V)**	**Declu. Pot. (V)**
PFBS	Perfluorobutanesulfonate	299 > 80	0.02	6	58	55
18O2-PFHxS	IDA	403 > 84	0.02	12	74	60
PFHpA	Perfluoroheptanoic acid	363 > 319	0.02	6	12	25
13C4-PFHpA	IDA	367 > 322	0.02	6	12	25
PFHxS	Perfluorohexanesulfonate	399 > 80	0.02	12	74	60
18O2-PFHxS	IDA	403 > 84	0.02	12	74	60
PFOA	Perfluorooctanoic acid	413 > 369	0.02	6	14	25
13C4PFOA	IDA	417 > 372	0.02	6	14	25
PFNA	Perfluorononanoic acid	463 > 419	0.02	6	14	25
13C5-PFNA	IDA	468 > 423	0.02	6	14	25
PFOS	Perfluorooctanesulfonate	499 > 80	0.02	9	108	65
13C4-PFOS	IDA	503 > 80	0.02	9	108	65

Table 1C				
Native Compounds	**Typical Native RT (minutes)**	**IS analog**	**Typical IDA RT (minutes)**	**Quantitation Method**
PFBS	6.68	18O2-PFHxS	7.76	Isotope Dilution
PFHpA	7.77	13C4-PFHpA	7.77	Isotope Dilution

Table 1C				
Native Compounds	**Typical Native RT (minutes)**	**IS analog**	**Typical IDA RT (minutes)**	**Quantitation Method**
PFHxS	7.76	18O2-PFHxS	7.76	Isotope Dilution
PFOA	8.44	13C4-PFOA	8.44	Isotope Dilution
PFNA	9.10	13C5-PFNA	9.10	Isotope Dilution
PFOS	9.06	13C4-PFOS	9.06	Isotope Dilution

11.2.2. Tune and calibrate the instrument as described in Section 10.

11.2.3. A typical run sequence is as follows:

- Primer (A number of primers are injected for conditioning of the instrument before analysis, especially when the instrument was idled or changed from a different analysis).
- Blank
- Calibration Curve
- ICB
- ICV
- PFOA RT marker (as needed)
- Rinse Blank (RB, not linked to anything)
- MB
- LCS
- LCSD (if applicable)
- Sample 1
- Sample 1 MS (if applicable)
- Sample 1 MSD (if applicable)
- Sample 2 (up to sample 10 before next CCV)
- CCV
- Up to 10 samples.
- End sequence with CCV

12. CALCULATIONS

Refer to Section 12 of the main body of this SOP for calculation information.

13. METHOD PERFORMANCE

Refer to Section 13 of the main body of this SOP for method performance information.

14. POLLUTION PREVENTION

Refer to Section 14 of the main body of this SOP for pollution prevention information.

15. WASTE MANAGEMENT

Refer to Section 15 of the main body of this SOP for waste management information.

16. REFERENCES

Refer to Section 16 of the main body of this SOP for reference information.

17. METHOD MODIFICATIONS

17.1. Refer to Section 17 of the main body of this SOP for modifications from Method 537, except as detailed below:

17.1.1. Water samples are prepared at 1.0 mL, not 250 mL.

17.1.2. Water sample containers are not preserved with Trizma. Holding time has been changed to 28 days for analysis.

17.1.3. The eluents and HPLC configuration differs. As a result the final extract is in 40:60 methanol:water.

18. ATTACHMENTS

There are no attachments to this Appendix.

19. REVISION HISTORY

Revisions prior to 04/10/2017 have been removed and are available in previous versions of this SOP.

19.1. WS-LC-0025, Attachment 1, Revision 3.0, Effective 04/13/2018

19.1.1. Updated labeling and formatting of Tables 1A-1C.

19.1.2. Added section 11.2.3, detailing a typical run sequence.

19.2. WS-LC-0025, Attachment 1, Revision 2.9, Effective 11/27/2017

19.2.1. No changes to the attachment with this revision.

19.3. WS-LC-0025, Attachment 1, Revision 2.8, Effective 11/06/2017

19.3.1. Section 11.2.1, Routine Instrument Operating Conditions table (SCIEX 5500), added “Minimum of 10 scans/peak”.

19.4. WS-LC-0025, Attachment 1, Revision 2.7, Effective 09/22/2017

19.4.1. Section 6.5, removed "The 5 items above are to be maintained in the drawer labeled "Segregated Supplies for in line SPE Analysis" in the LC/MS instrument room."

19.4.2. Added Sections 9.1 – 9.3.

19.4.3. Updated Section 11.1.

19.4.4. Editorial changes.

19.5. WS-LC-0025 Attachment 1, Revision 2.6, Effective 08/11/2017

19.5.1. No revisions to this attachment.

19.6. WS-LC-0025 Attachment 1, Revision 2.5, Effective 07/10/2017

19.6.1. No revisions to this attachment.

19.7. WS-LC-0025 Attachment 1, Revision 2.4, Effective 04/25/2017

19.7.1. No revisions to this attachment.

19.8. WS-LC-0025 Attachment 1, Revision 2.3, Effective 04/10/2017

19.8.1. Changed all mentions of "direct aqueous injection (DAI)" to "in line solid phase extraction (SPE)."

19.8.2. Inserted Section 17.1, and changed formatting of the modifications to Method 537 to Section 17.2 and subheadings.

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Title: Determination of Total Organic Carbon in Liquid Matrices [Methods 415.1, 9060, SM 5310B *and SM 5310C*]

Approvals

Signatures on File	
Stan Palmquist Date	Mike Ridenhower Date
Inorganic Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Dennis Bean Date
Quality Assurance Manager	Laboratory Director

Facility Distribution No. 001 **Distributed To:** Lab Intranet

1.0 Scope and Application

1.1 Analytes, Matrix(s), and Reporting Limits

This SOP describes the procedure for analysis of organic carbon in liquid matrices. Liquid matrices include groundwater, surface and saline waters, and domestic and industrial wastes. The standard reporting limit is 1.0 mg/L.

On occasion clients may request modifications to this SOP. These modifications are handled following the procedures outlined in Section 12.2.1 in the Quality Assurance Manual.

2.0 Summary of Method

Liquid samples are introduced into the carbonaceous analyzer. After the inorganic carbon component has been purged, the remaining organic carbon is converted to carbon dioxide by catalytic combustion or *UV-persulfate oxidation* (total carbon). An infrared detector then directly measures the carbon dioxide formed. The concentration of carbon dioxide is directly proportional to the total organic carbon in the sample.

3.0 Definitions

The quality control terms used in this procedure are consistent with SW-846 terminology. Definitions are provided in the glossary of the TestAmerica Seattle Quality Assurance Manual (QAM)

4.0 Interferences

4.1 For liquids, this procedure is applicable only to homogeneous samples with only slight amounts of sediment. Samples containing high levels of particulate matter can have reproducibility problems. Samples may have to be diluted for reproducible analysis.

4.2 Samples that contain or that are preserved with HCl will form HCl gas in TOC instruments. Since the analyzer is equipped with a gold lined sample cell use an NDIR to detect CO2 gas, the corrosive nature of HCl can damage the NDIR. The Apollo 9000 and *Phoenix 800* copper scrubbers manage to scrub out some HCl, but HCl breakthrough is common and causes NDIR detector corrosion.

4.3 Nitric Acid in combustion instruments will form N2O4, which is a corrosive gas. The copper and tin scrubber will remove some of the gas, but not all and there is the potential for corrosion in the detector.

4.4 Analysis of samples containing high concentration of salt offers a big challenge for high temperature combustion analyzers. Metal cations, such as sodium, have the effect of devitrifying the quartz combustion tube causing it to crystallize and break. Salts can also deposit on the catalyst resulting in a loss of efficiency.

5.0 Safety

Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001) and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.1 Specific Safety Concerns or Requirements

None

5.2 Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. **Note: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table.** A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Phosphoric Acid	Corrosive	1 Mg/M3 TWA	Inhalation is not an expected hazard unless misted or heated to high temperatures. May cause redness, pain, and severe skin burns. May cause redness, pain, blurred vision, eye burns, and permanent eye damage.
Sodium Persulfate	*Oxidizer Corrosive*	*0.1 Mg/M3-TWA as Persulfates*	*Causes irritation to the respiratory tract. Symptoms may include sore throat, shortness of breath, inflammation of nasal passages, coughing, and wheezing. Causes severe irritation or burns to the skin and eyes. Symptoms include redness, itching, pain and burns. May cause allergic skin reactions. Can cause eye damage.*
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			

6.0 Equipment and Supplies

6.1 Instrumentation

- Tekmar Apollo 9000 TOC Analyzer
- Tekmar Phoenix 8000 UV-Persulfate TOC Analyzer

6.2 Software

- TestAmerica LIMS (TALS), current version
- TOCTalk Ver *3.6.429 or 4.22.109*.

6.3 Supplies

- 40-mL VOA vials with septa

7.0 Reagents and Standards

7.1 Document reagent/standards and reagent/standard preparation in TALS using the reagent module as described in SOP TA-QA-0619.

7.2 ASTM Type II water

7.3 21% Phosphoric Acid

7.4 *10% Sodium Persulfate in 5% Phosphoric Acid*

7.5 1000-mg/L TOC Standard, Accu Standard P/N WC-TOC-10X-1 or equivalent.

7.6 1000-mg/L TOC Second Source Standard, Ultra Scientific P/N IQC-106 or equivalent

7.7 *0.5-mg/L TOC Standard prepared by diluting 20 microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 to 40 mL with DI water.*

7.8 1.0-mg/L TOC Standard prepared by diluting 40 microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 to 40 mL with DI water.

7.9 2.0-mg/L TOC Standard prepared by diluting 80 microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 standard to 40 mL with DI water.

7.10 5.0-mg/L TOC Standard prepared by diluting 200 microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 standard to 40 mL with DI water.

7.11 10-mg/L TOC Standard prepared by diluting 400 microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 standard to 40 mL with DI water.

7.12 20-mg/L TOC Standard prepared by diluting 800 microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 standard to 40 mL with DI water.

7.13 *40-mg/L TOC Standard prepared by diluting 1000 microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 standard to 40 mL with DI water.*

7.14 *10-mg/L* TOC Continuing Calibration Standard (CCV) and LCS Standard prepared by diluting *400* microliters of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 standard to 40 mL with DI water.

7.15 10-mg/L TOC Calibration Verification Standard (ICV) prepared by diluting 400-uL of the 1000-mg/L Ultra Scientific P/N IQC-106 standard to 40-mL with DI water.

7.16 Managers/supervisors or a designee are expected to check their areas on a monthly basis for expired standards and dispose of them according to SOP TA-EHS-0036.

8.0 Sample Collection, Preservation, Shipment and Storage

8.1 Samples should be stored at 0-6°C and protected from sunlight.

8.2 Samples can be collected in either glass or plastic containers.

8.3 Samples not analyzed within two hours of the time of sampling, must be acidified to pH less than 2 with H_2SO_4 or H_3PO_4. Sample preservation should be checked prior to analysis.

8.4 No holding specified for a preserved sample.

Matrix	Sample Container	Min. Sample Size	Preservation	Holding Time	Reference
Waters	Amber Glass *or HDPE*	50 mLs	H_2SO_4 or H_3PO_4, pH < 2; Cool 0-6°C	28 Days	40 CFR Part 136.3

9.0 Quality Control

9.1 The minimum quality controls (QC), acceptance criteria, and corrective actions are described in this section. When processing samples in the laboratory, use the LIMS special instructions to determine specific QC requirements that apply.

9.1.1 The laboratory's standard QC requirements, the process of establishing control limits, and the use of control charts are described more completely in SOP TA-QA-0620, Quality Control Program.

9.1.2 Project-specific requirements can override the requirements presented in this section when there is a written agreement between the laboratory and the client, and the source of those requirements should be described in the project documents. Project-specific requirements are communicated to the analyst via special instructions in the LIMS.

9.1.3 Any QC result that fails to meet control criteria must be documented in a Nonconformance Memo (NCM). The NCM is approved by the supervisor and then automatically sent to the laboratory Project Manager by e-mail so that the client can be notified as appropriate. The QA group also receives NCMs by e-mail for tracking and trending purposes. The NCM process is described in more detail in SOP TA-QA-0610. This is in addition to the corrective actions described in the following sections.

9.2 Batch Definition

A batch is a group of no greater than 10 samples excluding QC samples (Method Blank, LCS, and MS), which are processed similarly, with respect to the procedure. All samples within the batch must be treated with the same lots of reagents and the same processes.

9.3 Method Blank (MB)

One method blank (MB) must be processed with each batch. The method blank consists of DI water. The method blank is used to identify any system and process interferences or contamination of the analytical system that may lead to the reporting of elevated analyte concentrations or false positive data.

Acceptance Criteria: The method blank should not contain any analyte of interest above one-half the reporting limit.

Corrective Action: If the analyte level in the method blank exceeds one-half the reporting limit for the analytes of interest in the sample, all associated samples are re-prepared and reanalyzed. If this is not possible due to limited sample quantity or other considerations, the corresponding sample data must be taken in consultation with the client and must be addressed in the project narrative.

If there is no analyte greater than the RL in the samples associated with an unacceptable method blank, the data may be reported with qualifiers. Such action must be taken in consultation with the client and must be addressed in the project narrative.

If all samples associated with a blank greater than one-half the RL are greater than 10 times the blank value, the samples may be reported with an NCM to qualify the high blank value.

9.4 Laboratory Control Sample (LCS)

One LCS must be processed with each batch. The LCS is used to monitor the accuracy of the analytical process. On-going monitoring of the LCS results provides evidence that the laboratory is performing the method within acceptable accuracy and precision guidelines.

The LCS is prepared by adding 400-uL of the second source 1000-ug/mL TOC standard (section 7.5) to 40 mL DI water (10 mg/L).

Acceptance Criteria: The LCS recovery must fall within ±15% of the true value. The control limits are maintained in the LIMS.

Corrective Action: If any analyte is outside established control limits, the system is out of control, and corrective action must occur. Corrective action will be re-preparation and reanalysis of the batch unless the client agrees that other corrective action is acceptable.

9.5 Matrix Spike (MS) Samples

One MS must be processed for each batch. A matrix spike (MS) is a field sample to which known concentrations of target analytes have been added. Some client-specific data quality objectives (DQOs) may require the use of sample duplicates in place of or in addition to an MS. The MS results are used to determine the effect of a matrix on the accuracy of the analytical process. Due to the potential variability of the matrix of each sample, these results may have immediate bearing only on the specific sample spiked.

The MS is prepared by adding 400-uL of the second source 1000-ug/mL TOC standard (Section 7.5) to 40 mL sample volume.

Acceptance Criteria: The recovery of the analyte in the MS must fall within ±15% of the true value.

Corrective Action: If the analyte recovery falls outside the acceptance range, the recovery of that analyte must be in control for the LCS. If the recovery of the LCS is outside limits, corrective action must be taken. Corrective action will include re-preparation and reanalysis of the batch.

If an MS, MSD or sample duplicate is not possible due to limited sample volume then a laboratory control sample duplicate (LCSD) must be analyzed.

9.6 Duplicate Sample Analysis

A duplicate pair is required with each analytical batch and must be within 20% RPD. Note that the control limits only apply to samples with results greater than 5 times the RL. The process of establishing control limits is described in more detail in the QC SOP TA-QA-0620.

Corrective Action: If the RPD is greater than 20%, the sample should be reanalyzed if within holding time and sufficient sample is remaining.

9.7 **Instrument QC**

9.8 Calibration Acceptance Summary

The instrument calibration is verified each day prior to sample and method blank analysis; a single combustion of the appropriate standard must yield results within 15% of the true value in order to proceed.

9.9 Initial Calibration Verification (ICV)

The ICV standard is analyzed immediately following the ICAL. The ICV is a second-source TOC standard with a true value of 10 mg/L TOC (prepared by adding 400-uL of the second source 1000-ug/mL TOC standard (section 7.5) to 40 mL DI water). The analyte recovery must fall within the 85-115% range. If it is outside the acceptance limits, check the equipment and standards, correct any problems, and then recalibrate.

9.10 Continuing Calibration Verification (CCV)

The calibration is checked at the beginning of an analytical sequence (ICV), after every ten samples (CCV), and at the end of the sequence (CCV) by measuring a CCV standard.

The CCV is a TOC standard with a true value of 10 mg/L TOC (prepared by adding 400-uL of the 1000-mg/L Accu Standard P/N WC-TOC-10X-1 standard (section 7.4) to 40 mL DI water). The CCV recovery must be within the 85-115% range. If it is outside the acceptance limits, check the equipment and standards, correct any problems, recalibrate, and rerun all samples analyzed since the last successful CCV.

9.11 Initial and Continuing Calibration Blank (ICB and CCB)

System cleanliness is checked at the beginning of an analytical sequence, after every ten samples (CCB), and at the end of the sequence (CCB) by analyzing a blank.

The CCB for the automated method is DI water.

Results must be less than one-half the reporting limit. If the blank result is greater than one-half the reporting limit, check for carry-over from high level samples, clean the system, recalibrate, and rerun all samples analyzed since the last successful CCB.

Note: ICV/CCVs need to be followed by a ICB/CCB. ICV/CCVs cannot be preceded by a ICV/CCB unless a blank is analyzed before each sample in the bracket.

9.12 Any extra QC that is analyzed in a batch or sequence must be evaluated using the same criteria as the corresponding QC above.

10.0 Procedure

10.1 Sample Preparation

None

10.2 Instrument Operating Conditions

10.2.1 Instrument operating parameters are defined in the instrument's maintenance logbook. The absolute response of the daily ICV is evaluated and tracked in the logbook.

10.3 Calibration

10.3.1 A five-point calibration is performed using the standards specified in sections 7.6 through 7.10. Standard concentrations and volumes injected are programmed into the instrument before calibration. Standards are injected in duplicate by the autosampler; the instrument reports the average result.

10.3.2 The initial calibration is analyzed following the manufacturer's instructions for calibration.

10.3.3 The calibration points used must meet the criteria specified in corporate SOP CA-T-P-002.

10.3.4 The calibration standards listed in section 7.0 and a blank standard are analyzed.

10.3.5 The results are plotted in a calibration curve area vs. concentration (see corporate SOP CA-Q-S-005, Calibration Curves). The calibration curve is valid if the r-squared value is 0.995 or greater.

10.4 Sample Analysis

10.4.1 If a sample contains gross solids or insoluble matter, homogenize until satisfactory replication is obtained. Analyze a homogenizing blank consisting of reagent water carried through the homogenizing treatments. (SM5310B)

10.4.2 Ensure the compressed Zero grade air tank has sufficient pressure for the run. Also check that the DI water rinse container and 21% *reagent* containers are full and the waste container is empty.

10.4.3 On the main screen, click on the 'Setup' drop down menu, select 'Instrument' and click on the 'Ready' button on the new screen.

10.4.4 Allow the analyzer to warm up for thirty minutes or until baseline is stable (flow rate should be 200 ± 20 mL/min, furnace temperature should be 900° C).

10.4.5 Click on the 'Sample Setup' button. Update the rack ID by saving to a new file using a mmddyyyy format.

10.4.6 Enter all samples and QC in the sample table. The Sample Type should be 'Sample' for all samples and 'Cal Verification' for all ICVs, CCBs and CCVs. The Method should be set to 'TOC 0-20 ppmC'. When analyzing samples for either EPA 415.1 or SM 5310B the Reps should be set to '2'. When analyzing samples for Method 9060 the Reps should be set to '4'. The Status should be set at 'Ready'. Once the *sequence* is set up, click on 'Save and Use'. All replicates must integrate properly or the sample must be re-analyzed. If one or more of the replicates fails again, see your supervisor.

10.4.7 Label and fill the 40-ml VOA vials with standards and samples as they have been entered in the sample table.

10.4.8 On the main screen, click on 'Start'.

10.5 Standards and samples are analyzed in the following sequence:

Rinse
ICV
CCB
MB
LCS
QC sample
MS
MSD
5 samples
CCV
CCB
5 samples
New batch QC plus samples if over 10 samples are analyzed (Section 9.2)
CCV
CCB

10.6 Instrument Maintenance

All maintenance and repairs need to be documented in the instrument's maintenance logbook. The logbook must include the instrument name, serial number for each major component (e.g., GC, autosampler) and the date of start-up. When an instrument is not capable of analyzing samples, it needs to be tagged "Out of Service". Logbook entries must include a description of the problem and what actions were taken to address the problem. After an instrument has undergone maintenance or repairs, the system is evaluated using a CCV or ICAL. If the evaluation is successful, the analyst documents in the logbook that the "System returned to control as indicated by a passing CCV" (or ICAL, MB, etc as may be the case).

11.0 Calculations / Data Reduction

11.1 Calibration Curves

See corporate SOP CA-Q-S-005, Calibration Curves

11.2 Accuracy

ICV / CCV, LCS % Recovery = $\frac{\text{observed concentration}}{\text{known concentration}} \times 100$

MS % Recovery = $\frac{\text{(spiked sample) - (unspiked sample)}}{\text{spiked concentration}} \times 100$

11.3 Precision (RPD)

Matrix Duplicate (MD) = $\frac{|\text{orig. sample value - dup. sample value}|}{[(\text{orig. sample value + dup. sample value})/2]} \times 100$

11.4 Concentration = mg/L = C x D

Where:
C = sample concentration (ppm)
D = Dilution Factor

12.0 Method Performance

12.1 Method Detection Limit Study (MDL)

The method detection limit (MDL) is the lowest concentration that can be detected for a given analytical method and sample matrix with 99% confidence that the analyte is present. The MDL is determined according to the laboratory's MDL procedure (see SOP TA-QA-0602). MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. The laboratory maintains MDL studies for analyses performed; these are verified at least annually unless method requirements require a greater frequency.

12.2 Demonstration of Capabilities

Analyst initial and continuing Demonstrations of Capability (DOC) are performed before any client samples are analyzed and are updated annually. See SOP TA-QA-0617 for details.

12.3 Training Requirements

See SOP TA-QA-0608 for detailed training requirements.

13.0 Pollution Control

It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity needed, preparation of reagents based on anticipated usage and reagent stability).

14.0 Waste Management

Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes are disposed of in an accepted manner. Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to Waste Disposal SOP TA-EHS-0036.

14.1 Waste Streams Produced by the Method

14.1.1 Expired/off spec phosphoric acid may be disposed of into the neutralization tank.

15.0 References / Cross-References

15.1 *Phoenix 8000 UV-Persulfate TOC Analyzer Operating Manual.*

15.2 Apollo 9000 High Temperature TOC Analyzer Operating Manual.

15.3 Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983, Method 415.1.

15.4 Standard Methods for Analysis of Water and Wastewater, 19th Edition, 1995, Method 5310B.

15.5 SOP CA-Q-S-005, Calibration Curves

16.0 Method Modifications:

Item	Method	Modification
1	9060	Section 6.4 of Method 9060 specifies preserving samples with HCl or H_2SO_4. TestAmerica Seattle follows Tekmar Dohrman's recommendation of preserving samples with H_3PO_4.
2	9060	Section 7.1 of Method 9060 specifies homogenizing samples in a blender. If a sample contains gross solids or insoluble matter, homogenize until satisfactory replication is obtained. Analyze a homogenizing blank consisting of reagent water carried through the homogenizing treatments. (SM5310B).
3	9060	Section 7.3 of Method 9060 specifies purging the sample for 10 minutes with nitrogen. TestAmerica Seattle uses Tekmar Dohrman's method recommendation of purging for 4 minutes with zero air.
4	9060	Section 7.6 of Method 9060 specifies reporting both the average result and the range. TestAmerica Seattle only reports the average result

17.0 Attachments

None

18.0 Revision History

- Revision 10 dated 22 December 2015
  - Updated title to include SM 5310C
  - Updated to include the new UV-Persulfate instrument, sections 2.0, 4.2, 5.2, 61, 6.2, 7.0, 10.4.2 and 15.1.
  - Updated to include HDPE containers, section 8.4.

- Revision 9 dated 27 May 2015
  - Updated LCS preparation instructions and concentration, section 9.4.
  - Updated CCV preparation instructions and concentration, section 9.10.
  - Updated the replicates entered for analytical run based on the method being analyzed, section 10.4.6.
  - Removed section 10.4.9 as this is now covered in section 10.4.6 (see above).

- Revision 8 dated 31 May 2013
  - Updated Safety section 5.0.

- Changed ICV concentration from 5 to 10 mg/L to verify mid-point of curve, section 9.9.
- Added instructions on the preparation of the CCV/LCS, section 7.11 and 9.10.

- Revision 7 dated 2 April 2012
  - Revised method summary to reflect procedure used, section 2.0.
  - Changed ICV concentration from 15 to 5 mg/L to verify low end of curve, section 9.9 (LCS @ 15 mg/L verifies the middle of the curve).
  - Incorporated ROM 00033 in section 10.2.1.
  - Changed ICAL standard injections from quads to dups, section 10.3.1
  - Added method 415.1/5310 sample injection procedures (dups), Section 10.4.9
  - Updated sequence in section 10.5
  - Updated waste streams, section 14.1

- Revision 6 dated 6 December 2010
  - Replaced references for TestAmerica Tacoma with TestAmerica Seattle throughout document.
  - Updated standard sources, section 7.5 through 7.12
  - Revised method blank criteria for DOD QSM compliance Section 9.3
  - Incorporated ROMDs 00020 (section 10.1) 00022 (sections 10.3.5 and 11.1), 00024 (sections 9.9 and 9.10) 00025 (section 9.5)
  - Added sections 10.4.1, 10.4.2 and 10.4.7
  - Updated example sequence in Section 10.5
  - Added section on instrument maintenance, section 10.6
  - Updated item 2 (homogenization procedure) in Section (table) 16.0

- Revision 5 dated 12 November 2009
  - Added documentation of standards/reagents and standard/reagent preparation Section 7.1
  - Added removal of expired standards Section 7.12.
  - Added criteria for additional QC, Section 9.12.

- Revision 4 dated 5 November 2008
  - Removed pH check in sample preparation section.
- Revision 3, dated 26 December 2007
  - Integration for TestAmerica and STL operations.
  - Removed higher-level calibration standards that are no longer in use.
  - Added acceptance limits for airflow.
  - Updated the combustion chamber temperature from 680°C to 900°C.
  - Updated the instrument method name from TCO1-400 to TOC1-20mg/L.
  - Updated sample analysis from triplicate to quadruplicate.
  - Added sample duplicate frequency.
  - Removed the modification that samples are analyzed in triplicate.

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Title: Total Organic Carbon in Solids Using the LECO C632 Total Organic Carbon Analyzer [Methods SW846 9060 Mod, 9060A Mod and PSEP-TOC]

Approvals

Signatures on File

Stan Palmquist Date
Inorganic Department Manager

Joe Schairer Date
Health & Safety Manager / Coordinator

Terri Torres Date
Quality Assurance Manager

Dennis Bean Date
Laboratory Director

Facility Distribution No. 001 **Distributed To:** Lab Intranet

1.0 Scope and Application

1.1 This procedure describes the determination of total organic carbon in soils, sludge, and sediments using the LECO C632 TOC analyzer. The LECO instrument uses 0.20 gram quantities of sample, and so results are less prone to precision problems that are typical of the trace TOC instruments that use sample aliquots in the 10-100 mg range. The method referenced for this procedure is EPA Method 9060.

1.2 The reporting limit (RL) is 0.2% carbon or 2,000 mg/kg.

1.3 On occasion clients may request modifications to this SOP. These modifications are handled following the procedures outlined in Section 12.2.1 in the Quality Assurance Manual

2.0 Summary of Method

The sample is treated with 6N (1:1) HCL or 5% phosphoric Acid to drive off inorganic carbonates and then dried to remove moisture and acid. Organic carbon in the sample is converted to carbon dioxide (CO_2) by catalytic combustion. The CO_2 formed is measured by an infrared detector. The amount of CO_2 is directly proportional to the concentration of carbonaceous material in the sample.

3.0 Definitions

Total Organic Carbon (TOC):

The carbon measured as a result of oxidation of the sample after the removal of inorganic carbon.

4.0 Interferences

4.1 Oily samples will cause erratic results. This is minimized by homogenization of the sample.

4.2 This procedure is applicable to samples that can be thoroughly homogenized into a fine powder.

5.0 Safety

Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001) and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.1 Specific Safety Concerns or Requirements

Spent crucibles must be allowed to cool to room temperature prior to disposal.

5.2 Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. **Note: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the SDS for each of the materials listed in the table.** A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the SDS for each material before using it for the first time or when there are major changes to the SDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Hydrochloric Acid	Corrosive Poison	5 ppm-Ceiling	Inhalation of vapors can cause coughing, choking, inflammation of the nose, throat, and upper respiratory tract, and in severe cases, pulmonary edema, circulatory failure, and death. Can cause redness, pain, and severe skin burns. Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.
5% Phosphoric Acid	Irritant Corrosive	1 mg/L TWA	Severe Chemical burns. Pain with skin contact, ingestion or inhalation. Can cause permanent damage to lungs. Maybe fatal if swallowed or inhaled.
1 – Always add acid to water to prevent violent reactions. 2 – Exposure limit refers to the OSHA regulatory exposure limit.			

6.0 Equipment and Supplies

6.1 Instrumentation

- LECO C632 Analyzer
- Oven - The temperature must be sufficient to drive off water and acid and dry the samples

6.2 Computer Software and Hardware

- Computer with a minimum 1GB memory, Pentium 4 processor, 80 G hard drive or equivalent or as recommended by instrument manufacturer.
- LECO's proprietary computer interface and computer data handling system
- LIMS system: TALS version 1.0 or higher

6.3 Supplies

- Porcelain Combustion Boats
- Small Beakers
- Spoons or spatulas
- Miscellaneous volumetric glassware
- Compressed gas duster cans
- Aluminum weighing dishes
- 20 ml disposable scintillation vials
- Mortar and pestle

7.0 Reagents and Standards

7.1 Phosphoric, 5%.

Add 5.9 ml of 85% H_3PO_4 to 100 mL of deionized (DI) water
(Either the HCl or the Phosphoric acid can be used to remove the inorganic carbon.)

7.2 6N Hydrochloric Acid (1:1)

Slowly and carefully and with stirring, add 500 mL of concentrated HCL to 500 mL of deionized (DI) water. Allow to cool before use.

7.3 TOC Calibration Standard (MS/MSD/CCV)

Low Level: Calcium Carbonate; 12.00%C
High Level: Potassium Biphthalate, 47.05%C

7.4 TOC Initial Calibration Verification (ICV) This standard is from a different source than that of 7.2.

Low Level: Calcium Carbonate; 12.00%C
High Level: Potassium Biphthalate, 47.05%C

7.5 TOC Calibration Standard (LCS)

This standard is purchased from ERA. The true value will be dependent on the lot received.

8.0 Sample Collection, Preservation, Shipment and Storage

Sample container, preservation techniques and holding times may vary and are dependent on sample matrix, method of choice, regulatory compliance, and/or specific contract or client requests. Listed below are the holding times and the references that include preservation requirements.

Matrix	Sample Container	Min. Sample Size	Preservation	Holding Time	Reference
Soils	Glass	3 Grams	Cool 0-6°C	14 Days for PSDDA/PSEP/SMS 28 days for all other. Sediments may be frozen extending holding time for up to 6 months.	N/A

9.0 Quality Control

9.1 The minimum quality controls (QC), acceptance criteria, and corrective actions are described in this section. When processing samples in the laboratory, use the LIMS QC program code and special instructions to determine specific QC requirements that apply.

9.1.1 The laboratory's standard QC requirements, the process of establishing control limits, and the use of control charts are described more completely in TestAmerica Seattle SOP TA-QA-0620, Quality Control Program.

9.1.2 Project-specific requirements can override the requirements presented in this section when there is a written agreement between the laboratory and the client, and the source of those requirements should be described in the project documents. Project-specific requirements are communicated to the analyst via special instructions in the LIMS.

9.1.3 Any QC result that fails to meet control criteria must be documented in a Nonconformance Memo (NCM). The NCM is approved by the supervisor and then automatically sent to the laboratory Project Manager by e-mail so that the client can be notified as appropriate. The QA group also receives NCMs by e-mail for tracking and trending purposes. The NCM process is described in more detail in

SOP TA-QA-0610. This is in addition to the corrective actions described in the following sections.

9.2 Batch Definition

A batch is a group of no greater than 20 samples excluding QC samples (LCS, MS, MSD, Method Blanks), which are processed similarly, with respect to the procedure. All samples within the batch must be treated with the same lots of reagents and the same processes.

9.3 Method Blank (MB)

One method blank (MB) must be processed with each batch. The method blank consists of a solid blank matrix (typically Ottawa Sand) containing all reagents specific to the method that is carried through the entire analytical procedure, including preparation and analysis. The method blank is used to identify any system and process interferences or contamination of the analytical system that may lead to the reporting of elevated analyte concentrations or false positive data.

Acceptance Criteria: The method blank should not contain any analyte of interest above one-half the reporting limit.

Corrective Action: If the analyte level in the method blank exceeds one-half the reporting limit for the analytes of interest in the sample, all associated samples are re-prepared and reanalyzed. If this is not possible due to limited sample quantity or other considerations, the corresponding sample data must be taken in consultation with the client and must be addressed in the project narrative.

If there is no analyte greater than the RL in the samples associated with an unacceptable method blank, the data may be reported with qualifiers. Such action must be taken in consultation with the client and must be addressed in the project narrative.

If all samples associated with a blank greater than the RL are greater than 10 times the blank value, the samples may be reported with an NCM to qualify the high blank value.

9.4 Laboratory Control Sample (LCS)

One LCS must be processed with each batch. The LCS is used to monitor the accuracy of the analytical process. On-going monitoring of the LCS results provides evidence that the laboratory is performing the method within acceptable accuracy and precision guidelines.

The LCS for TOC in soils is performed by analyzing a 0.20 g aliquot of an ERA CRM (see Section 7.5). The LCS is prepared by slowly add 5% Phosphoric Acid and watch for the sample to fizz. If there is no fizzing then the sample is ready to be dried in the oven. If the sample fizzes then more 5% Phosphoric Acid needs to be added. Continue adding 5% Phosphoric Acid until the fizzing stops. (1:1 HCl can also be used)

Acceptance Criteria: The LCS recovery must fall within the established control limits certified by the vendor. The control limits are maintained in the LIMS.

Corrective Action: If any analyte is outside established control limits, the system is out of control, and corrective action must occur. Corrective action

will be re-preparation and reanalysis of the batch unless the client agrees that other corrective action is acceptable.

9.5 Matrix Spike and Matrix Spike Duplicate (MS/MSD) Samples

One MS/MSD pair must be processed for each batch. A matrix spike (MS) is a field sample to which known concentrations of target analytes have been added. A matrix spike duplicate (MSD) is a second aliquot of the same sample (spiked identically as the MS) that is prepared and analyzed along with the sample and matrix spike. Some client specific data quality objectives (DQOs) may require the use of sample duplicates in place of or in addition to an MS/MSD pair. The MS/MSD results are used to determine the effect of a matrix on the precision and accuracy of the analytical process. Due to the potential variability of the matrix of each sample, these results may have immediate bearing only on the specific sample spiked.

The MS and MSD for the automated method are prepared by placing 0.10g of the soil sample to be spiked into a porcelain boat and adding an identical weight of calcium carbonate. These are mixed and combusted as a sample with the weight of the soil (0.10 g) used as the sample weight in the sample table. The mass of the calcium carbonate used is typed into the “description” field of the LECO software run log.

Acceptance Criteria: The recovery of the analyte in the MS and MSD must fall within +-20% of the true value.

Corrective Action: If the analyte recovery or RPD falls outside the acceptance range, the recovery of that analyte must be in control for the LCS. If the recovery of the LCS is outside limits, corrective action must be taken. Corrective action will include re-preparation and reanalysis of the batch.

If an MS/MSD is not possible due to limited sample volume then a laboratory control sample duplicate (LCSD) should be analyzed.

9.6 Duplicate Sample Analysis

A duplicate pair is required with each analytical batch and must be within 50% RPD. Note that the control limits only apply to samples with results greater than 5 times the RL. The process of establishing control limits is described in more detail in the QC SOP TA-QA-0620.

Corrective Action: If the RPD is greater than 50% the sample should be reanalyzed if within holding time and sufficient sample is remaining.

Note: Samples analyzed under the PSEP protocol require one sample per batch of 20 to be analyzed in triplicate. *Triplicate = 6 burns total for the sample chosen for triplicate; sample – 2 burns, duplicate (DU) – 2 burns and triplicate (TRL) – 2 burns.*

Note: Samples analyzed for the USACE require analysis in quadruplicate for all samples.

9.7 <u>Instrument QC</u>

9.8 Initial Calibration Verification (ICV)

The ICV standard is analyzed immediately following the ICAL. The ICV is a second-source calcium carbonate standard with a true value of 12% carbon. The analyte recovery must fall within the 80-120% range. If it is outside the acceptance limits, check the equipment and standards, correct any problems, and then recalibrate.

9.9 Continuing Calibration Verification (CCV)

The calibration is checked at the beginning of an analytical sequence (ICV), after every ten samples (CCV), and at the end of the sequence (CCV) by measuring a CCV standard.

The CCV is calcium carbonate with a true value of 12% carbon.

The CCV recovery must be within the 80-120% range. If it is outside the acceptance limits, check the equipment and standards, correct any problems, recalibrate, and rerun all samples analyzed since the last successful CCV.

9.10 Initial and Continuing Calibration Blank (ICB and CCB)

System cleanliness is checked at the beginning of an analytical sequence (ICB), after every ten samples (CCB), and at the end of the sequence (CCB) by analyzing a blank.

The ICB/CCB for the automated method is a solid sample matrix.

Results must be less than the reporting limit. If the blank result is greater than the reporting limit, check for carry-over from high level samples, clean the system, recalibrate, and rerun all samples analyzed since the last successful CCB.

9.11 Test for Selection Efficiency

Once a year or as part of a new analyst's demonstration of capability, the efficiency of inorganic carbon removal for a solid matrix will be checked by splitting a sample containing at least 10K mg/Kg TOC into two portions, adding to one portion an inorganic carbon level similar to that of the sample. The TOC for both portions will be determined and the values compared. If the TOC values don't agree within ±20% RPD (for TOC concentrations at least 5 times the RL), adjust the sample volume or the amount of acid added to the sample to obtain complete removal of the inorganic carbon.

9.12 Any extra QC that is analyzed in a batch or sequence must be evaluated using the same criteria as the corresponding QC above

10.0 Procedure

One time procedural variations are allowed only if deemed necessary in the professional judgment of supervisor to accommodate variation in sample matrix, radioactivity, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using a Nonconformance Memo and is approved by a Technical Specialist and QA Manager. If contractually required, the client shall be notified. The Nonconformance Memo shall be filed in the project file.

Any unauthorized deviations from this procedure must also be documented as a nonconformance, with a cause and corrective action described.

10.1 Sample Preparation

10.1.1 Place a 2-3 gram sample in a dry weight tin. Slowly add 5% Phosphoric Acid and watch for the sample to fizz. If there is no fizzing then the sample is ready to be dried in the oven. If the sample fizzes then more 5% Phosphoric Acid needs to be added. Continue adding 5% Phosphoric Acid until the fizzing stops. (1:1 HCl can also be used)

10.1.2 Heat the samples in an oven maintained at 70℉ ± 2° F until they appear dry.

10.1.3 After drying, the samples should be homogenized, and ground to uniform consistency using a clean mortar and pestle. Clean the mortar and pestle by dusting with the compressed air duster and then wiping with a clean KimWipe. Leave out any extraneous artifacts, i.e., glass shards, large twigs, leaves, etc.

10.2 Instrument Operating Conditions

10.2.1 Instrument operating parameters are defined in the instrument's maintenance logbook. The absolute response of the daily ICV is evaluated and tracked in the logbook.

10.3 Calibration

10.3.1 Calibration should be performed whenever a ICV or CCV fails QC criteria or following major instrument maintenance. The calibration typically will be good for up to six months.

10.3.2 Instrument and furnace should be left on at all times. Be sure that the furnace is reheated to 1350℃ before beginning analysis.

10.3.3 If the furnace has been shut down due to maintenance or a power failure, ramp the temperature up slowly to 600℃ to minimize the ther mal stresses on the combustion tube.

10.3.4 Turn on the compressed air to the autosampler and the oxygen to the combustion analyzer.

10.3.5 Check that the incoming oxygen pressure is 20-40 psi and the combustion pressure is <15 psi.

10.3.6 An initial calibration is performed annually, or as needed. based on the instrument performance and maintenance.

10.3.7 Initial Calibration: The LECO analyzer is calibrated with calcium carbonate, a solid with a true value of 12% carbon and blanks.

10.3.7.1 Analyze three blanks

10.3.7.2 Analyze a six point standard curve (0.050g, 0.075g, 0.100g, 0.150g, 0.200g and 0.250g) with the 12% carbon standard.

10.3.8 The results are plotted in a calibration curve area vs. concentration (see corporate SOP CA-Q-S-005, Calibration Curves).

Acceptance Criteria:	The absolute value of the correlation coefficient (r) must be 0.995 or greater. The correlation coefficient can be determined by subtracting the RMS Error from the ICAL report from 1.
Corrective Action:	If the correlation coefficient is less than the acceptance limit, recheck instrument conditions and calibration standards. Samples cannot be analyzed until the initial calibration is successful.

10.4 Sample Analysis

10.4.1 Weigh approximately 0.20 g of homogenized and dried sample into a new, compressed air dusted, tared porcelain weigh boat. Spread the sample evenly throughout the boat. With the cursor in the "mass" column, push the read button on the balance to add the weight of the sample to the LECO software run log.

10.4.2 Load the samples into the auto sampler. After the samples are loaded, use the software to begin analysis.

10.4.3 Unless there are special project requirements, all instrument and batch QC is analyzed as a single analysis, while all samples are analyzed as two replicates (or "in duplicate"). For the QC sample, the sample duplicate and triplicate are substituted for the two replicates.

10.4.4 Sample results should be less than 20% carbon so that they use the calibrated low-range IR cell. Sample results of greater than 20% carbon should be reanalyzed with a smaller aliquot. (This equates to about 2.5 to 3 million counts, right around the high point on the curve)

10.4.5 Samples and standards are measured in the following sequence:

ICV
ICB
MB
LCS
LCSD (IF NEEDED)
QC SAMPLE
QC DUPLICATE
QC TRIPLICATE (IF NEEDED)
QC MS
QC MSD
2-4 SAMPLES (FOR A TOTAL OF 10 SAMPLES)
CCV
CCB
10 SAMPLES
CCV
CCB

10.5 Data Review

First and second level data reviews are recorded on the Wet Chemistry Data Review Checklist.

10.5.1 Upon completion of the analytical run, the primary analyst must review all data for compliance with criteria documented in Sections 9.0 and 10 and evaluate control charts according to SOP TA-QA-0600. The primary analyst will enter the data into TALS upon completion of their initial review and update the status.

10.5.2 The Supervisor (or designate) must perform a secondary peer review of the data as entered into TALS. Upon satisfactory completion of this review, the Supervisor (or designate) will update the status of the data set to second level reviewed, indicating the data is ready for reporting to the client.

10.6 Instrument Maintenance

The level of gasses must be checked before each analysis to insure they do not need to be replaced. All maintenance and repairs need to be documented in the instrument's maintenance logbook. The logbook must include the instrument name, serial number for each major component (e.g., GC, auto sampler) and the date of start-up. When an instrument is not capable of analyzing samples, it needs to be tagged "Out of Service". Logbook entries must include a description of the problem and what actions were taken to

address the problem. After an instrument has undergone maintenance or repairs, the system is evaluated using a CCV or ICAL. If the evaluation is successful, the analyst documents in the logbook that the "System returned to control as indicated by a passing CCV" (or ICAL, MB, etc as may be the case). Raw data counts are recorded in the maintenance logbook for each passing ICV.

10.7 Troubleshooting

If you are experiencing low recovery of QC samples check the desiccant. If it starts to appear solid or if there is a color change it will need to be changed per manufactures instructions.

If samples will not run make sure to check the temperature setting for the furnace to insure it is set correctly.

11.0 Calculations / Data Reduction

11.1 Calibration Curves

Detailed calibration equations can be found in the corporate SOP CA-Q-S-005 "Calibration Curves".

11.2 Accuracy

$$\textbf{ICV / CCV, LCS \% Recovery} = \frac{\text{observed concentration}}{\text{known concentration}} \times 100$$

$$\textbf{MS \% Recovery} = \frac{\text{(spiked sample) - (unspiked sample)}}{\text{spiked concentration}} \times 100$$

11.3 Precision (RPD)

$$\textbf{Matrix Duplicate (MD)} = \frac{|\text{orig. sample value - dup. sample value}|}{[(\text{orig. sample value + dup. sample value})/2]} \times 100$$

11.4 Concentration =

$$\text{mg/kg or L} = \frac{C \times V \times D}{W}$$

Where:

C = sample concentration in extract (ppm)
V = Volume of extract (mL)
D = Dilution Factor
W = Weight/Volume of sample aliquot extracted (grams or mLs)

NOTE: TOC analysis should not be dry weight corrected. TOC samples are dried prior to analysis. If a client requires the true dry weight correction at 104C (PSEP) then the total solids should be analyzed twice, once at 70C and once at the normal 104 C and both reported to the client.

11.5 Control limits are stored in and accessed from LIMS.

11.6 The detection limit for this method will vary based on the results of detection limit studies performed. Samples less than the method detection limit are reported as ND. Please refer to LIMS for current reporting limit information.

12.0 Method Performance

12.1 Method Detection Limit Study (MDL)

The method detection limit (MDL) is the lowest concentration that can be detected for a given analytical method and sample matrix with 99% confidence that the analyte is present. The MDL is determined according to the laboratory's MDL procedure (see SOP TA-QA-0602). MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. The laboratory maintains MDL studies for analyses performed; these are verified at least annually unless method or program requirements require a greater frequency.

12.2 Demonstration of Capabilities

Analyst initial and continuing Demonstration of Capabilities (DOC) are performed before any client samples are analyzed and are updated annually. See SOP TA-QA-0617 for details.

12.3 Training Requirements

See SOP-TA-QA-0608 for detailed training requirements.

13.0 Pollution Control

It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity needed, preparation of reagents based on anticipated usage and reagent stability).

14.0 Waste Management

14.1 Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes are disposed of in an accepted manner. Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to Waste Disposal SOP TA-EHS-0036.

14.2 The following waste streams are produce when this method is carried out:

14.2.1 Acidic waste: Is bulked into the Metals Digest Waste Stream which is sent out for waste water treatment.

14.2.2 Porcelain Combustion Boats: Are dispose of into the "Dirt Samples and Debris" waste stream which is sent out for incineration.

14.2.3 Foreign soil waste and materials contaminated during sample preparation are collected for autoclaving and disposal per SOP TA-QA-0531.

15.0 References / Cross-References

15.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Third Edition and all promulgated updates, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, January 2005, Method 9060,Total Organic Carbon, Revision 0, September 1986.

15.2 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Third Edition and all promulgated updates, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, January 2005, Method 9060A, Total Organic Carbon, Revision 1, November 2004.

15.3 Puget Sound Estuary Protocols, Conventional Sediment Variables, Total Organic Carbon, March 1986.

15.4 Puget Sound Estuary Protocols, Conventional Sediment Variables, Recommended Guidelines for measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples, April 1997.

16.0 Method Modifications:

Item	Method	Modification
1	SW 9060	Method 9060 is designed for water samples and requires quadruplicate analysis to overcome potential precision problems. This procedure is exclusively for soil samples, and the LECO instrument is designed for soil analysis. The sample aliquots are 10-100 times larger than are practical with most other non-dispersive IR instruments, and so the precision is acceptable with duplicate analyses.
2	SW 9060	Method 9060 requires the use of a blender to homogenize samples. Since this procedure is for soils, the samples are ground to a uniform consistency.

17.0 Attachments

None

18.0 Revision History

- Revision 4, dated 26 September 2016
  - Changed MSDS to SDS, section 5.2
  - Added detail for triplicate analysis, section 9.6
- Revision 3, dated 29 September 2015
  - Added recording of raw data counts of passing ICVs, section 10.6
- Revision 2, dated 22 September 2014
  - Added computer hardware and software, section 6.2
  - Added supplies, section 6.3
  - Added clarification to holding time requirements, section 8.0
  - Added requirement to record weight of spike for MS/MSD, section 9.5
  - Added detail on cleaning Mortar and pestle, 10.1.3
  - Clarified when calibration should be performed, section 10.3.1
  - Updated calibration from five points to six points, section 10.3.6.2
  - Updated analysis sequence, section 10.4.5
  - Added checking gas levels to section 10.6
  - Added troubleshooting section, 10.7
  - Added details on true dry weight at 104C to section 11.4
  - Updated waste streams, section 14.2
- Revision 1, dated 29 July 2013
  - Added 5% Phosphoric Acid to multiple sections of the SOP
  - Changed the weight of sample used for the MS/MSD in section 9.5
  - Updated waste streams, section 14.2
- Revision 0, dated 6 July 2012
  - Initial release.

Determination of Selected Perfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)

Reference: EPA Method 537, Version 1.1, September 2009, EPA Document #: EPA/600/R-08/092

Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 5.1, 2016

1. Scope and Application

Matrices: Drinking Water, Non-potable water, Soil

Definitions: Refer to Alpha Analytical Quality Manual.

1.1 This is a liquid chromatography/tandem mass spectrometry (LC/MS/MS) method for the determination of selected perfluorinated alkyl substances (PFASs) in drinking water. Accuracy and precision data have been generated in reagent water, and finished ground and surface waters for the compounds listed in Table 1.

1.2 The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

1.3 This method is restricted to use by or under the supervision of analysts experienced in the operation of the LC/MS/MS and in the interpretation of LC/MS/MS data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

Table 1

Parameter	Acronym	CAS
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	-
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	-
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorotetradecanoic acid	PFTA	376-06-7
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluoroundecanoic acid	PFUnA	2058-94-8

2. Summary of Method

2.1 A 250-mL water sample is fortified with surrogates and passed through a solid phase extraction (SPE) cartridge containing polystyrenedivinylbenzene (SDVB) to extract the method analytes and surrogates. The compounds are eluted from the solid phase with a small amount of methanol. The extract is concentrated to dryness with nitrogen in a heated water bath, and then adjusted to a 1-mL volume with 96:4% (vol/vol) methanol:water after adding the IS(s). A 10-µL injection is made into an LC equipped with a C18 column that is interfaced to an MS/MS. The analytes are separated and identified by comparing the acquired mass spectra and retention times to reference spectra and retention times for calibration standards acquired under identical LC/MS/MS conditions. The concentration of each analyte is determined by using the internal standard technique. Surrogate analytes are added to all Field and QC Samples to monitor the extraction efficiency of the method analytes.

2.2 Method Modifications from Reference

2.2.1 None.

3. Reporting Limits

3.1 The reporting limit for PFAS's is 2 ng/L.

4. Interferences

4.1 All glassware must be meticulously cleaned. Wash glassware with detergent and tap water, rinse with tap water, followed by a reagent water rinse. Non-volumetric glassware can be heated in a muffle furnace at 400 °C for 2 hours or solvent rinsed. Volumetric glassware should be solvent rinsed and not be heated in an oven above 120 °C. Store clean glassware inverted or capped. Do not cover with aluminum foil because PFASs can be potentially transferred from the aluminum foil to the glassware.

4.1.1 **NOTE:** PFAS standards, extracts and samples should not come in contact with any glass containers or pipettes as these analytes can potentially adsorb to glass surfaces. PFAS analyte, IS and SUR standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in polypropylene containers.

4.2 Method interferences may be caused by contaminants in solvents, reagents (including reagent water), sample bottles and caps, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. The method analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) products, LC solvent lines, methanol, aluminum foil, SPE sample transfer lines, etc. All items such as these must be routinely demonstrated to be free from interferences (less than 1/3 the RL for each method analyte) under the conditions of the analysis by analyzing laboratory reagent blanks as described in Section 9.2. **Subtracting blank values from sample results is not permitted.**

4.3 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending

upon the nature of the water. Humic and/or fulvic material can be co-extracted during SPE and high levels can cause enhancement and/or suppression in the electrospray ionization source or low recoveries on the SPE sorbent. Total organic carbon (TOC) is a good indicator of humic content of the sample. Under the LC conditions used during method development, matrix effects due to total organic carbon (TOC) were not observed.

4.4 Relatively large quantities of the preservative (Sect. 6.2.1) are added to sample bottles. The potential exists for trace-level organic contaminants in these reagents. Interferences from these sources should be monitored by analysis of laboratory reagent blanks (Sect. 9.2.1), particularly when new lots of reagents are acquired.

4.5 SPE cartridges can be a source of interferences. The analysis of field and laboratory reagent blanks can provide important information regarding the presence or absence of such interferences. Brands and lots of SPE devices should be tested to ensure that contamination does not preclude analyte identification and quantitation.

5. Health and Safety

5.1 The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

5.2 All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.3 PFOA has been described as “likely to be carcinogenic to humans.” Pure standard materials and stock standard solutions of these method analytes should be handled with suitable protection to skin and eyes, and care should be taken not to breathe the vapors or ingest the materials.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

6.1.1 Samples must be collected in three (3) 250-mL polypropylene bottles fitted with a polypropylene screw-cap.

6.1.2 The sample handler must wash their hands before sampling and wear nitrile gloves while filling and sealing the sample bottles. PFAS contamination during sampling can occur from a number of common sources, such as food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will aid in minimizing this type of accidental contamination of the samples.

6.1.3 Open the tap and allow the system to flush until the water temperature has stabilized (approximately 3 to 5 min). Collect samples from the flowing system.

6.1.4 Fill sample bottles, taking care not to flush out the sample preservation reagent. Samples do not need to be collected headspace free.

6.1.5 After collecting the sample, cap the bottle and agitate by hand until preservative is dissolved. Keep the sample sealed from time of collection until extraction.

6.1.6 Field Reagent Blank (FRB)

6.1.6.1 A FRB must be handled along with each sample set. The sample set is composed of samples collected from the same sample site and at the same time. At the laboratory, fill the field blank sample bottle with reagent water and preservatives, seal, and ship to the sampling site along with the sample bottles. For each FRB shipped, an empty sample bottle (no preservatives) must also be shipped. At the sampling site, the sampler must open the shipped FRB and pour the preserved reagent water into the empty shipped sample bottle, seal and label this bottle as the FRB. The FRB is shipped back to the laboratory along with the samples and analyzed to ensure that PFASs were not introduced into the sample during sample collection/handling.

6.1.6.2 The same batch of preservative must be used for the FRBs as for the field samples.

6.1.6.3 The reagent water used for the FRBs must be initially analyzed for method analytes as a MB and must meet the MB criteria in Section 9.2.1 prior to use. This requirement will ensure samples are not being discarded due to contaminated reagent water rather than contamination during sampling.

6.2 Sample Preservation

6.2.1 The preservation reagent, listed in the table below, is added to each sample bottle as a solid prior to shipment to the field (or prior to sample collection).

Table 2

Compound	Amount	Purpose
Trizma	5.0 g/l	Buffering reagent and removes free chlorine

6.3 Sample Shipping

6.3.1 Samples must be chilled during shipment and must not exceed 10 °C during the first 48 hours after collection. Sample temperature must be confirmed to be at or below 10 °C when the samples are received at the laboratory. Samples stored in the lab must be held at or below 6 °C until extraction, but should not be frozen.

NOTE: Samples that are significantly above 10° C, at the time of collection, may need to be iced or refrigerated for a period of time, in order to chill them prior to shipping. This will allow them to be shipped with sufficient ice to meet the above requirements.

6.4 Sample Handling

6.4.1 Holding Times

6.4.1.1 Water samples should be extracted as soon as possible but must be extracted within 14 days. Extracts must be stored at room temperature and analyzed within 28 days after extraction.

7. Equipment and Supplies

7.1 SAMPLE CONTAINERS – 250-mL polypropylene bottles fitted with polypropylene screw caps. Sample bottles must be discarded after use.

7.2 POLYPROPYLENE BOTTLES – 4-mL narrow-mouth polypropylene bottles.

7.3 CENTRIFUGE TUBES – 15-mL conical polypropylene tubes with polypropylene screw caps for storing standard solutions and for collection of the extracts.

7.4 AUTOSAMPLER VIALS – Polypropylene 0.3-mL autosampler vials with polypropylene caps.

7.4.1 NOTE: Polypropylene vials and caps are necessary to prevent contamination of the sample from PTFE coated septa. However, polypropylene caps do not reseal, so evaporation occurs after injection. Thus, multiple injections from the same vial are not possible.

7.5 POLYPROPYLENE GRADUATED CYLINDERS – Suggested sizes include 25, 50, 100 and 1000-mL cylinders.

7.6 MICRO SYRINGES – Suggested sizes include 5, 10, 25, 50, 100, 250, 500 and 1000-µL syringes.

7.7 PLASTIC PIPETS – Polypropylene or polyethylene disposable pipets.

7.8 ANALYTICAL BALANCE – Capable of weighing to the nearest 0.0001 g.

7.9 SOLID PHASE EXTRACTION (SPE) APPARATUS FOR USING CARTRIDGES

7.9.1 SPE CARTRIDGES – 0.5 g, 6-mL SPE cartridges containing styrenedivinylbenzene (SDVB) sorbent phase.

7.9.2 VACUUM EXTRACTION MANIFOLD – A manual vacuum manifold with Visiprep large volume sampler for cartridge extractions, or an automatic/robotic sample preparation system designed for use with SPE cartridges, may be used if all QC requirements discussed in Section 9 are met. Extraction and/or elution steps may not be changed or omitted to accommodate the use of an automated system. Care must be taken with automated SPE systems to ensure the PTFE commonly used in these systems does not contribute to unacceptable analyte concentrations in the MB (Sect. 9.2.1).

7.9.3 SAMPLE DELIVERY SYSTEM – Use of a polypropylene transfer tube system, which transfers the sample directly from the sample container to the SPE cartridge, is recommended, but not mandatory. Standard extraction manifolds come equipped with PTFE transfer tube systems. These can be replaced with 1/8” O.D. x 1/16” I.D. polypropylene or polyethylene tubing cut to an appropriate length to ensure no sample contamination from the sample transfer lines. Other types of non-PTFE tubing may be used provided it meets the MB (Sect. 9.2.1) and LCS (Sect. 9.3) QC requirements. The PTFE transfer tubes may be used, but an MB must be run on each PFTE transfer tube and the QC requirements in Section 13.2.2 must be met. In the case of automated SPE, the removal of PTFE lines may not be feasible; therefore, MBs will need to be rotated among the ports and must meet the QC requirements of Sections 13.2.2 and 9.2.1.

7.10 EXTRACT CONCENTRATION SYSTEM – Extracts are concentrated by evaporation with nitrogen using a water bath set no higher than 65 °C.

7.11 LABORATORY OR ASPIRATOR VACUUM SYSTEM – Sufficient capacity to maintain a vacuum of approximately 10 to 15 inches of mercury for extraction cartridges.

7.12 LIQUID CHROMATOGRAPHY (LC)/TANDEM MASS SPECTROMETER (MS/MS) WITH DATA SYSTEM

7.12.1 LC SYSTEM – Instrument capable of reproducibly injecting up to 10-µL aliquots, and performing binary linear gradients at a constant flow rate near the flow rate used for development of this method (0.3 mL/min). The LC must be capable of pumping the water/methanol mobile phase without the use of a degasser which pulls vacuum on the mobile phase bottle (other types of degassers are acceptable). Degassers which pull vacuum on the mobile phase bottle will volatilize the ammonium acetate mobile phase causing the analyte peaks to shift to earlier retention times over the course of the analysis batch. The usage of a column heater is optional.

NOTE: During the course of method development, it was discovered that while idle for more than one day, PFASs built up in the PTFE solvent transfer lines. To prevent long delays in purging high levels of PFASs from the LC solvent lines, they were replaced with PEEK tubing and the PTFE solvent frits were replaced with stainless steel frits. It is not possible to remove all PFAS background contamination, but these measures help to minimize their background levels.

7.12.2 LC/TANDEM MASS SPECTROMETER – The LC/MS/MS must be capable of negative ion electrospray ionization (ESI) near the suggested LC flow rate of 0.3 mL/min. The system must be capable of performing MS/MS to produce unique product ions for the method analytes within specified retention time segments. A minimum of 10 scans across the chromatographic peak is required to ensure adequate precision.

7.12.3 DATA SYSTEM – An interfaced data system is required to acquire, store, reduce, and output mass spectral data. The computer software should have the capability of processing stored LC/MS/MS data by recognizing an LC peak within any given retention time window. The software must allow integration of the ion abundance of any specific ion within specified time or scan number limits. The software must be able to calculate relative response factors, construct linear regressions or quadratic calibration curves, and calculate analyte concentrations.

7.12.4 ANALYTICAL COLUMN – An LC C_{18} column (2.1 x 150 mm) packed with 5 µm d_p C_{18} solid phase particles was used. Any column that provides adequate resolution, peak shape, capacity, accuracy, and precision (Sect. 9) may be used.

8. Reagents and Standards

8.1 GASES, REAGENTS, AND SOLVENTS – Reagent grade or better chemicals should be used.

8.1.1 REAGENT WATER – Purified water which does not contain any measurable quantities of any method analytes or interfering compounds greater than 1/3 the RL for each method analyte of interest. Prior to daily use, at least 3 L of reagent water should be flushed from the purification system to rinse out any build-up of analytes in the system's tubing.

8.1.2 METHANOL (CH_3OH, CAS#: 67-56-1) – High purity, demonstrated to be free of analytes and interferences.

8.1.3 AMMONIUM ACETATE ($NH_4C_2H_3O_2$, CAS#: 631-61-8) – High purity, demonstrated to be free of analytes and interferences.

8.1.4 20 mM AMMONIUM ACETATE/REAGENT WATER – To prepare 1 L, add 1.54 g ammonium acetate to 1 L of reagent water. This solution is prone to volatility losses and should be replaced at least every 48 hours.

8.1.5 TRIZMA PRESET CRYSTALS, pH 7.0 – Reagent grade. A premixed blend of Tris [Tris(hydroxymethyl)aminomethane] and Tris HCL [Tris(hydroxymethyl)aminomethane hydrochloride]. Alternatively, a mix of the two components with a weight ratio of 15.5/1 Tris HCL/Tris may be used. These blends are targeted to produce a pH near 7.0 at 25 °C in reagent water. Trizma functions as a buffer, and removes free chlorine in chlorinated finished waters (Sect. 6.2.1).

8.1.6 NITROGEN – Used for the following purposes: Nitrogen aids in aerosol generation of the ESI liquid spray and is used as collision gas in some MS/MS instruments. The nitrogen used should meet or exceed instrument manufacturer's specifications. In addition, Nitrogen is used to concentrate sample extracts (Ultra High Purity or equivalent).

8.1.7 ARGON – Used as collision gas in MS/MS instruments. Argon should meet or exceed instrument manufacturer's specifications. Nitrogen gas may be used as the collision gas provided sufficient sensitivity (product ion formation) is achieved.

8.2 STANDARD SOLUTIONS – When a compound purity is assayed to be 96% or greater, the weight can be used without correction to calculate the concentration of the stock standard. PFAS analyte, IS and SUR standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in polypropylene containers. Standards for sample fortification generally should be prepared in the smallest volume that can be accurately measured to minimize the addition of excess organic solvent to aqueous samples.

NOTE: Stock standards (Sect. 8.2.1, 8.2.3 and 8.2.5) are stored at ≤4 °C. Primary dilution standards (Sect. 8.2.2 and 8.2.4) are stored at room temperature to prevent adsorption of the method analytes onto the container surfaces that may occur when refrigerated. Storing the standards at room temperature will also minimize daily imprecision due to the potential of inadequate room temperature stabilization.

8.2.1 IS STOCK STANDARD SOLUTIONS - IS stock standard solutions are stable for at least 6 months when stored at 4 °C. The stock solution is purchased at a concentration range of 1-4 ng/µl.

8.2.2 INTERNAL STANDARD PRIMARY DILUTION (IS PDS) STANDARD (0.5-2 ng/µL) – Prepare the IS PDS at a concentration of 0.5-2 ng/µL. The IS PDS is prepared in 96:4% (vol/vol) methanol:water. The IS PDS is stable for at least two months when stored in polypropylene centrifuge tubes at room temperature.

Table 3

Internal Standard	Conc. of IS Stock (ng/uL)	Vol. of IS Stock (mL)	Final Vol. of IS PDS (mL)	Final Conc. of IS PDS (ng/µL)
^{13}C-PFOA	1	1.0	2.0	0.5
^{13}C-PFOS	3	1.0	2.0	1.5
D_3-NMeFOSAA	4	1.0	2.0	2.0

8.2.3 SUR STOCK STANDARD SOLUTIONS – SUR stock standard solutions are stable for at least 6 months when stored at 4 °C.

8.2.4 SURROGATE PRIMARY DILUTION STANDARD (SUR PDS) (0.5-2 ng/µL) – Prepare the SUR PDS at a concentration of 0.5-2 ng/µL. The SUR PDS is prepared in 96:4% (vol/vol) methanol:water. This solution is used to fortify all QC and Field Samples. The PDS is stable for one year when stored in polypropylene centrifuge tubes at room temperature.

Table 4

Surrogate	Conc. of SUR Stock (ng/µL)	Vol. of SUR Stock (mL)	Final Vol. of SUR PDS (,L)	Final Conc. of SUR PDS (ng/µL)
^{13}C-PFHxA	1.0	1.0	2.0	0.5
^{13}C-PFDA	1.0	1.0	2.0	0.5
d_5-NEtFOSAA	4.0	1.0	2.0	2.0

8.2.5 ANALYTE STOCK STANDARD SOLUTION – Analyte stock standards are stable for at least 6 months when stored at -15 °C. When using these stock standards to prepare a PDS, care must be taken to ensure that these standards are at room temperature and adequately vortexed.

Table 5

Analyte	Analyte Stock Solvent	Concentration (ug/mL)
PFHxA	96:4% (vol/vol) methanol:water	1.0
PFHpA	96:4% (vol/vol) methanol:water	1.0
PFOA	96:4% (vol/vol) methanol:water	1.0
PFNA	96:4% (vol/vol) methanol:water	1.0
PFDA	96:4% (vol/vol) methanol:water	1.0
PFUnA	96:4% (vol/vol) methanol:water	1.0
PFDoA	96:4% (vol/vol) methanol:water	1.0
PFTrDA	100% ethyl acetate	1.0
PFTA	100% ethyl acetate	1.0
PFBS	100% methanol	1.0
PFHxS	100% methanol	1.0
PFOS	100% methanol	1.0
NEtFOSAA	100% methanol	1.0
NMeFOSAA	100% methanol	1.0

8.2.6 LOW, MEDIUM AND HIGH LEVEL LCS – The LCS's will be prepared at the following concentrations and rotated per batch; 2 ng/L, 40 ng/L, 500 ng/l. The analyte PDS contains all the method analytes of interest at various

concentrations in methanol containing 4% water. The analyte PDS has been shown to be stable for 6 months when stored at room temperature.

8.2.7 CALIBRATION STANDARDS (CAL) –

Current Concentrations (ng/mL): 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 30.0, 40.0, 50.0, 125 and 150 (optional)

Prepare the CAL standards over the concentration range of interest from dilutions of the analyte PDS in methanol containing 4% reagent water. The IS and SUR are added to the CAL standards at a constant concentration (10-40 ng/L). The lowest concentration CAL standard must be at or below the RL (2 ng/L), which may depend on system sensitivity. The CAL standards may also be used as CCVs (Sect. 9.9). The CAL standards are stable for at least two weeks when stored at room temperature. Longer storage times are acceptable provided appropriate QC measures are documented demonstrating the CAL standard stability.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 REPORTING LIMIT (RL) CONFIRMATION

9.1.1 Fortify, extract, and analyze seven replicate LCSs at 2 ng/l. These LCSs must contain all method preservatives described in Section 6.2.1. Calculate the mean measured concentration (*Mean*) and standard deviation for these replicates. Determine the Half Range for the prediction interval of results (HR_{PIR}) using the equation below

$$HR_{PIR} = 3.963s$$

Where:

s = the standard deviation
3.963 = a constant value for seven replicates.

9.1.2 Confirm that the upper and lower limits for the Prediction Interval of Result ($PIR = Mean \pm HR_{PIR}$) meet the upper and lower recovery limits as shown below

The Upper PIR Limit must be ≤150% recovery.

$$\frac{Mean + HR_{PIR}}{Fortified\ Concentration} \times 100\% \leq 150\%$$

The Lower PIR Limit must be ≥ 50% recovery.

$$\frac{Mean - HR_{PIR}}{Fortified\ Concentration} \times 100\% \geq 50\%$$

9.1.3 The RL is validated if both the Upper and Lower PIR Limits meet the criteria described above. If these criteria are not met, the RL has been set too low and must be determined again at a higher concentration.

9.2 Blank(s)

9.2.1 **METHOD BLANK (MB)** - A Method Blank (MB) is required with each extraction batch to confirm that potential background contaminants are not interfering with the identification or quantitation of method analytes. If more than 20 Field Samples are included in a batch, analyze an MB for every 20 samples. If the MB produces a peak within the retention time window of any analyte that would prevent the determination of that analyte, determine the source of contamination and eliminate the interference before processing samples. Background contamination must be reduced to an acceptable level before proceeding. Background from method analytes or other contaminants that interfere with the measurement of method analytes must be below 1/3 of the RL. Blank contamination is estimated by extrapolation, if the concentration is below the lowest CAL standard. This extrapolation procedure is not allowed for sample results as it may not meet data quality objectives. If the method analytes are detected in the MB at concentrations equal to or greater than this level, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch. Because background contamination is a significant problem for several method analytes, it is highly recommended that the analyst maintain a historical record of MB data.

9.2.2 **FIELD REAGENT BLANK (FRB)** - The purpose of the FRB is to ensure that PFASs measured in the Field Samples were not inadvertently introduced into the sample during sample collection/handling. Analysis of the FRB is required only if a Field Sample contains a method analyte or analytes at or above the RL. The FRB is processed, extracted and analyzed in exactly the same manner as a Field Sample. If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the RL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed.

9.3 Laboratory Control Sample (LCS)

9.3.1 An LCS is required with each extraction batch. The fortified concentration of the LCS must be rotated between low, medium, and high concentrations from batch to batch.

9.3.2 The low concentration LCS must be as near as practical to, but no more than two times, the RL. Similarly, the high concentration LCS should be near the high end of the calibration range established during the initial calibration (Sect. 10.6).

9.3.3 Results of the low-level LCS analyses must be 50-150% of the true value. Results of the medium and high-level LCS analyses must be 70-130% of the true value. If the LCS results do not meet these criteria for method analytes, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch.

9.3.4 It is the responsibility of the extraction chemist to view the previous extraction batch to determine the next spiking concentration. (Low → Medium → High)

9.4 Internal Standards (IS)

The analyst must monitor the peak areas of the IS(s) in all injections during each analysis day. The IS responses (peak areas) in any chromatographic run must be within 70-140% of the response in the most recent CCV and must not deviate by more than 50% from the average area measured during initial analyte calibration. If the IS areas in a chromatographic run do not meet these criteria, inject a second aliquot of that extract aliquoted into a new capped autosampler vial. Random evaporation losses have been observed with the polypropylene caps causing high IS(s) areas.

9.4.1 If the reinjected aliquot produces an acceptable IS response, report results for that aliquot.

9.4.2 If the reinjected extract fails again, the analyst should check the calibration by reanalyzing the most recently acceptable CAL standard. If the CAL standard fails the criteria of Section 9.9, recalibration is in order per Section 10.6. If the CAL standard is acceptable, extraction of the sample may need to be repeated provided the sample is still within the holding time. Otherwise, report results obtained from the reinjected extract, but annotate as suspect. Alternatively, collect a new sample and re-analyze.

9.5 Surrogate Recovery

The SUR standard is fortified into all samples, CCVs, MBs, LCSs, MSs, MSDs, FD, and FRB prior to extraction. It is also added to the CAL standards. The SUR is a means of assessing method performance from extraction to final chromatographic measurement. Calculate the recovery (%R) for the SUR using the following equation

$$\%R = (A / B) \times 100$$

Where:

A = calculated SUR concentration for the QC or Field Sample
B = fortified concentration of the SUR.

9.5.1.1 SUR recovery must be in the range of 70-130%. When SUR recovery from a sample, blank, or CCV is less than 70% or greater than 130%, check 1) calculations to locate possible errors, 2) standard solutions for degradation, 3) contamination, and 4) instrument performance. Correct the problem and reanalyze the extract.

9.5.1.2 If the extract reanalysis meets the SUR recovery criterion, report only data for the reanalyzed extract.

9.5.1.3 If the extract reanalysis fails the 70-130% recovery criterion, the analyst should check the calibration by injecting the last CAL standard that passed. If the CAL standard fails the criteria of Section 10.7, recalibration is in order per Section 10.6. If the CAL standard is acceptable, extraction of the sample should be repeated provided the sample is still within the holding time. If the re-extracted sample also fails the recovery criterion, report all data for that sample as suspect/SUR recovery to inform the data user that the results are suspect due to SUR recovery. Alternatively, collect a new sample and re-analyze.

9.6 Matrix Spike (MS)

9.6.1 Analysis of an MS is required in each extraction batch and is used to determine that the sample matrix does not adversely affect method accuracy. Assessment of method precision is accomplished by analysis of a Field Duplicate (FD) (Sect. 9.7); however, infrequent occurrence of method analytes would hinder this assessment. If the occurrence of method analytes in the samples is infrequent, or if historical trends are unavailable, a second MS, or MSD, must be prepared, extracted, and analyzed from a duplicate of the Field Sample. Extraction batches that contain MSDs will not require the extraction of a field sample duplicate. If a variety of different sample matrices are analyzed regularly, for example, drinking water from groundwater and surface water sources, method performance should be established for each. Over time, MS data should be documented by the laboratory for all routine sample sources.

9.6.2 Within each extraction batch, a minimum of one Field Sample is fortified as an MS for every 20 Field Samples analyzed. The MS is prepared by spiking a sample with an appropriate amount of the Analyte Stock Standard (Sect. 8.2.5). Use historical data and rotate through the low, mid and high concentrations when selecting a fortifying concentration. Calculate the percent recovery (%*R*) for each analyte using the equation

$$\%R = \frac{(A - B)}{C} \times 100$$

Where:

A = measured concentration in the fortified sample
B = measured concentration in the unfortified sample
C = fortification concentration.

9.6.3 Analyte recoveries may exhibit matrix bias. For samples fortified at or above their native concentration, recoveries should range between 70-130%, except for low-level fortification near or at the RL (within a factor of 2-times the RL concentration) where 50-150% recoveries are acceptable. If the accuracy of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the CCVs, the recovery is judged to be matrix biased. The result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.7 Laboratory Duplicate

9.7.1 FIELD DUPLICATE OR LABORATORY FORTIFIED SAMPLE MATRIX DUPLICATE (FD or MSD) – Within each extraction batch (not to exceed 20 Field Samples), a minimum of one FD or MSD must be analyzed. Duplicates check the precision associated with sample collection, preservation, storage, and laboratory procedures. If method analytes are not routinely observed in Field Samples, an MSD should be analyzed rather than an FD.

9.7.2 Calculate the relative percent difference (*RPD*) for duplicate measurements (*FD1* and *FD2*) using the equation

$$RPD = \frac{|FD1 - FD2|}{(FD1 + FD2) / 2} \times 100$$

9.7.3 RPDs for FDs should be ≤30%. Greater variability may be observed when FDs have analyte concentrations that are within a factor of 2 of the RL. At these

concentrations, FDs should have RPDs that are ≤50%. If the RPD of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the CCV, the recovery is judged to be matrix biased. The result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.7.4 If an MSD is analyzed instead of a FD, calculate the relative percent difference (RPD) for duplicate MSs (MS and MSD) using the equation

$$RPD = \frac{|MS - MSD|}{(MS + MSD) / 2} \times 100$$

9.7.5 RPDs for duplicate MSs should be ≤30% for samples fortified at or above their native concentration. Greater variability may be observed when MSs are fortified at analyte concentrations that are within a factor of 2 of the RL. MSs fortified at these concentrations should have RPDs that are ≤50% for samples fortified at or above their native concentration. If the RPD of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the CCV, the recovery is judged to be matrix biased. The result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.8 Initial Calibration Verification (ICV)

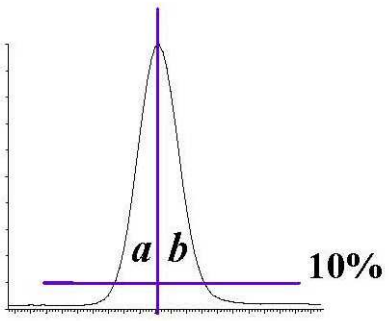
9.8.1 As part of the IDC (Sect. 13.2), each time a new Analyte Stock Standard solution (Sect. 8.2.5) is used, and at least quarterly, analyze a QCS sample from a source different from the source of the CAL standards. If a second vendor is not available, then a different lot of the standard should be used. The QCS should be prepared and analyzed just like a CCV. Acceptance criteria for the QCS are identical to the CCVs; the calculated amount for each analyte must be ± 30% of the expected value. If measured analyte concentrations are not of acceptable accuracy, check the entire analytical procedure to locate and correct the problem.

9.9 Continuing Calibration Verification (CCV)

9.9.1 CCV Standards are analyzed at the beginning of each analysis batch, after every 10 Field Samples, and at the end of the analysis batch. See Section 10.7 for concentration requirements and acceptance criteria.

9.10 Method-specific Quality Control Samples

9.10.1 PEAK ASYMMETRY FACTOR – A peak asymmetry factor must be calculated using the equation below during the IDL and every time a calibration curve is generated. The peak asymmetry factor for the first two eluting peaks in a midlevel CAL standard (if only two analytes are being analyzed, both must be evaluated) must fall in the range of 0.8 to 1.5. Modifying the standard or extract composition to more aqueous content to prevent poor shape is not permitted. See



guidance in Section 10.6.4.1 if the calculated peak asymmetry factors do not meet the criteria.

$$A_s = b / a$$

Where:

A_s = peak asymmetry factor
b = width of the back half of the peak measured (at 10% peak height) from the trailing edge of the peak to a line dropped perpendicularly from the peak apex
a = the width of the front half of the peak measured (at 10% peak height) from the leading edge of the peak to a line dropped perpendicularly from the apex.

9.11 Method Sequence

ICV

CCV-LOW

MB

LCS

LCSD

MS

Duplicate or MSD

Field Samples (1-10)

CCV-MID

Field Samples (11-20)

CCV-HIGH

10. Procedure

10.1 Equipment Set-up

10.1.1 This procedure may be performed manually or in an automated mode using a robotic or automatic sample preparation device. If an automated system is used to prepare samples, follow the manufacturer's operating instructions, but all extraction and elution steps must be the same as in the manual procedure. Extraction and/or elution steps may not be changed or omitted to accommodate the use of an automated system. If an automated system is used, the MBs should be rotated among the ports to ensure that all the valves and tubing meet the MB requirements (Sect. 9.2).

10.1.2 Some of the PFASs adsorb to surfaces, including polypropylene. Therefore, the aqueous sample bottles must be rinsed with the elution solvent (Sect 10.3.4) whether extractions are performed manually or by automation. The bottle rinse is passed through the cartridge to elute the method analytes and is then collected (Sect. 10.3.4).

10.1.3 **NOTE:** The SPE cartridges and sample bottles described in this section are designed as single use items and should be discarded after use. They may not be refurbished for reuse in subsequent analyses.

10.2 Sample Preparation

10.2.1 Samples are preserved, collected and stored as presented in Section 6. All Field and QC Samples, including the MB, LCS and FRB, must contain the dechlorinating agent listed in Section 6.2.1. Determine sample volume. An indirect measurement may be done in one of two ways: by marking the level of the sample on the bottle or by weighing the sample and bottle to the nearest 10 g. After extraction, proceed to Section 10.5 for final volume determination. Some of the PFASs adsorb to surfaces, thus the sample volume may **NOT** be transferred to a graduated cylinder for volume measurement. The MB, LCS and FRB may be prepared by measuring 250 mL of reagent water with a polypropylene graduated cylinder or filling a 250-mL sample bottle to near the top.

The entire sample that is received must be sent through the SPE cartridge. In addition, the bottle must be solvent rinsed and this rinse must be sent through the SPE cartridge as well. The method blank (MB) and laboratory control sample (LCS) must be extracted in exactly the same manner (i.e., must include the bottle solvent rinse). It should be noted that a water rinse alone is not sufficient. This does not apply to samples with high concentrations of PFAS that are prepared using serial dilution and not SPE.

10.2.2 Add 20 µL of the SUR PDS (Sect. 8.2.4) to each sample, cap and invert to mix for a final concentration of 10 ng/L for ^{13}C-PFHxA and ^{13}C-PFDA and 40 ng/L for d_5-NEtFOSAA.

10.2.3 In addition to the SUR(s) and dechlorination agent, if the sample is an LCS, MS, or MSD, add the necessary amount of analyte PDS (Sect. 8.2.5). Cap and invert each sample to mix.

10.3 Cartridge SPE Procedure

10.3.1 CARTRIDGE CLEAN-UP AND CONDITIONING – DO NOT allow cartridge packing material to go dry during any of the conditioning steps. Rinse each cartridge with 15 mL of methanol. Next, rinse each cartridge with 18 mL of reagent water, without allowing the water to drop below the top edge of the packing. If the cartridge goes dry during the conditioning phase, the conditioning must be started over. Add 4-5 mL of reagent water to each cartridge, attach the sample transfer tubes (Sect. 7.2.3), turn on the vacuum, and begin adding sample to the cartridge.

10.3.2 SAMPLE EXTRACTON – Adjust the vacuum so that the approximate flow rate is 10-15 mL/min. Do not allow the cartridge to go dry before all the sample has passed through.

10.3.3 SAMPLE BOTTLE AND CARTRIDGE RINSE – After the entire sample has passed through the cartridge, rinse the sample bottles with two 7.5-mL aliquots of reagent water and draw each aliquot through the sample transfer tubes and the cartridges. Draw air or nitrogen through the cartridge for 5 min at high vacuum (10-15 in. Hg).

NOTE: If empty plastic reservoirs are used in place of the sample transfer tubes to pass the samples through the cartridges, these reservoirs must be

treated like the transfer tubes. After the entire sample has passed through the cartridge, the reservoirs must be rinsed to waste with reagent water.

10.3.4 SAMPLE BOTTLE AND CARTRIDGE ELUTION – Turn off and release the vacuum. Lift the extraction manifold top and insert a rack with collection tubes into the extraction tank to collect the extracts as they are eluted from the cartridges. Rinse the sample bottles with 4 mL of methanol and elute the analytes from the cartridges by pulling the 4 mL of methanol through the sample transfer tubes and the cartridges. Use a low vacuum such that the solvent exits the cartridge in a dropwise fashion. Repeat sample bottle rinse and cartridge elution with a second 4-mL aliquot of methanol.

NOTE: If empty plastic reservoirs are used in place of the sample transfer tubes to pass the samples through the cartridges, these reservoirs must be treated like the transfer tubes. After the reservoirs have been rinsed in Section 10.3.3, the elution solvent used to rinse the sample bottles must be swirled down the sides of the reservoirs while eluting the cartridge to ensure that any method analytes on the surface of the reservoirs are transferred to the extract.

10.4 Extract Concentration

10.4.1 Concentrate the extract to dryness under a gentle stream of nitrogen in a heated water bath (60-65 °C) to remove all the water/methanol mix. Add the appropriate amount of 96:4% (vol/vol) methanol:water solution and the IS PDS (Sect. 8.2.2) to the collection vial to bring the volume to 1 mL and vortex. Transfer a small aliquot with a plastic pipet (Sect. 7.6) to a polypropylene autosampler vial.

NOTE: It is recommend that the entire 1-mL aliquot not be transferred to the autosampler vial because the polypropylene autosampler caps do not reseal after injection. Therefore, do not store the extracts in the autosampler vials as evaporation losses can occur occasionally in these autosampler vials. Extracts can be stored in 15-mL centrifuge tubes (Sect. 7.3).

10.5 Sample Volume Determination

10.5.1 If the level of the sample was marked on the sample bottle, use a graduated cylinder to measure the volume of water required to fill the original sample bottle to the mark made prior to extraction. Determine to the nearest 10 mL. If using weight to determine volume, weigh the empty bottle to the nearest 10 g and determine the sample weight by subtraction of the empty bottle weight from the original sample weight (Sect. 10.2.1). Assume a sample density of 1.0 g/mL. In either case, the sample volume will be used in the final calculations of the analyte concentration (Sect. 11.2).

10.6 Initial Calibration - Demonstration and documentation of acceptable initial calibration is required before any samples are analyzed. After the initial calibration is successful, a CCV is required at the beginning and end of each period in which analyses are performed, and after every tenth Field Sample.

10.6.1 ESI-MS/MS TUNE

10.6.1.1 Calibrate the mass scale of the MS with the calibration compounds and procedures prescribed by the manufacturer.

10.6.1.2 Optimize the [M-H]- for each method analyte by infusing approximately 0.5-1.0 µg/mL of each analyte (prepared in the initial mobile phase conditions) directly into the MS at the chosen LC mobile phase flow rate (approximately 0.3 mL/min). This tune can be done on a mix of the method analytes. The MS parameters (voltages, temperatures, gas flows, etc.) are varied until optimal analyte responses are determined. The method analytes may have different optima requiring some compromise between the optima.

10.6.1.3 Optimize the product ion for each analyte by infusing approximately 0.5-1.0 µg/mL of each analyte (prepared in the initial mobile phase conditions) directly into the MS at the chosen LC mobile phase flow rate (approximately 0.3 mL/min). This tune can be done on a mix of the method analytes. The MS/MS parameters (collision gas pressure, collision energy, etc.) are varied until optimal analyte responses are determined. Typically, the carboxylic acids have very similar MS/MS conditions and the sulfonic acids have similar MS/MS conditions.

10.6.2 Establish LC operating parameters that optimize resolution and peak shape. Modifying the standard or extract composition to more aqueous content to prevent poor shape is not permitted.

Cautions: LC system components, as well as the mobile phase constituents, contain many of the method analytes in this method. Thus, these PFASs will build up on the head of the LC column during mobile phase equilibration. To minimize the background PFAS peaks and to keep background levels constant, the time the LC column sits at initial conditions must be kept constant and as short as possible (while ensuring reproducible retention times). In addition, prior to daily use, flush the column with 100% methanol for at least 20 min before initiating a sequence. It may be necessary on some systems to flush other LC components such as wash syringes, sample needles or any other system components before daily use.

Mobile phase modifiers other than 20 mM ammonium acetate may be used at the discretion of the analyst, provided that the retention time stability criteria in Sect. 10.9.2 can be met over a period of two weeks. During method development, retention times shifted to shorter and shorter times as days progressed when mobile phases with less than 20 mM ammonium acetate were used.

10.6.3 Inject a mid-level CAL standard under LC/MS conditions to obtain the retention times of each method analyte. If analyzing for PFTA, ensure that the LC conditions are adequate to prevent co-elution of PFTA and the mobile phase interferants. These interferants have the same precursor and products ions as PFTA, and under faster LC conditions may co-elute with PFTA. Divide the chromatogram into retention time windows each of which contains one or more chromatographic peaks. During MS/MS analysis, fragment a small number of selected precursor ions ([M-H]-) for the analytes in each window and choose the most abundant product ion. For maximum sensitivity, small mass windows of ±0.5 daltons around the product ion mass were used for quantitation. If sufficient sensitivity exists to meet the RL, wider mass ranges may be used to obtain more confirmation ions.

10.6.3.1 **As recommended by the EPA Advisory on September 2016, both linear and branched isomers should e included in the quantitation. NOTE: As the NOTE in Section 10.6.4.1 indicates, PFOS has linear and branched isomers. There have been reports that not all the products ions in the linear PFOS are produced in all the branched PFOS isomers. (This phenomenon probably exists for PFHxS and PFBS also, although it has not been studied to date.) Thus, in an attempt to reduce PFOS bias, it is required that the *m/z* 499 → *m/z* 80 transition be used as the quantitation transition. Some MS/MS instruments, such as conventional ion traps, may not be able to scan a product ion with such a wide mass difference from the precursor ion; therefore, they may not be used for this method if PFOS, PFBS, or PFHxS analysis is to be conducted. Literature reports indicate for the most abundant PFOS isomer, which is the linear isomer, that all the products ions obtained on an ion trap have less than 10% relative abundance. In addition, there is not a single ion trap MS/MS transition that encompasses the linear isomer and the majority of the branch isomers; thus, the bias would be unacceptably high.**

10.6.4 Inject a mid-level CAL standard under optimized LC/MS/MS conditions to ensure that each method analyte is observed in its MS/MS window and that there are at least 10 scans across the peak for optimum precision.

10.6.4.1 If broad, split or fronting peaks are observed for the first two eluting chromatographic peaks (if only two analytes are being analyzed, both must be evaluated), change the initial mobile phase conditions to higher aqueous content until the peak asymmetry ratio for each peak is 0.8 – 1.5. The peak asymmetry factor is calculated as described in Section 9.10.1 on a mid-level CAL standard. The peak asymmetry factor must meet the above criteria for the first two eluting peaks during the IDL and every time a new calibration curve is generated. Modifying the standard or extract composition to more aqueous content to prevent poor shape is not permitted.

NOTE: PFHxS, PFOS, NMeFOSAA, and NEtFOSAA have multiple chromatographic peaks using the LC conditions in Table 5 due to chromatographic resolution of the linear and branched isomers of these compounds. According to the EPA Advisory, September 2016, the branched isomers are identified by analyzing a qualitative/semi-qualitative mixed PFOA standard and the quantitation of PFOA is accomplished by integration the total response which includes peaks identified as linear and branched isomers. Most PFASs are produced by two different processes. One process gives rise to linear PFASs only while the other process produces both linear and branched isomers. Thus, both branched and linear PFASs can potentially be found in the environment. For the aforementioned compounds that give rise to more than one peak, all the chromatographic peaks observed in the standard must be integrated and the areas totaled. Chromatographic peaks in a sample must be integrated in the same way as the CAL standard.

10.6.5 Prepare a set of CAL standards as described in Section 8.2.7. The lowest concentration CAL standard must be at or below the RL (2 ng/L), which may

depend on system sensitivity. It is recommended that at least four of the CAL standards are at a concentration greater than or equal to the RL.

10.6.6 The LC/MS/MS system is calibrated using the IS technique. Use the LC/MS/MS data system software to generate a linear regression or quadratic calibration curve for each of the analytes. This curve **must always** be forced through zero and may be concentration weighted, if necessary. Forcing zero allows for a better estimate of the background levels of method analytes.

10.6.6.1 The isotopically labeled IS(s) in this method may undergo suppression in the ESI source if the concentration of the co-eluting unlabeled method analyte(s) is too high. The analyte concentration at which suppression may occur can vary depending on the instrument, LC conditions, ESI conditions, IS concentration, etc. To evaluate whether suppression is occurring during calibration, calculate the relative percent difference (*RPD*) between the high (H) and low (L) areas for each IS using the equation

$$RPD = \frac{(H - L)}{(H + L) / 2} \times 100$$

10.6.6.2 The RPD calculated above must be <20% for each IS during calibration. If the calculated RPD is >20% for any IS, the analyst must recalibrate at lower analyte concentrations until the IS RPDs are <20%.

10.6.7 CALIBRATION ACCEPTANCE CRITERIA – When quantitated using the initial calibration curve, each calibration point, except the lowest point, for each analyte should calculate to be within 70-130% of its true value. The lowest CAL point should calculate to be within 50-150% of its true value. If these criteria cannot be met, the analyst will have difficulty meeting ongoing QC criteria. It is recommended that corrective action is taken to reanalyze the CAL standards, restrict the range of calibration, or select an alternate method of calibration (forcing the curve through zero is still required).

10.6.7.1 **CAUTION:** When acquiring MS/MS data, LC operating conditions must be carefully reproduced for each analysis to provide reproducible retention times. If this is not done, the correct ions will not be monitored at the appropriate times. As a precautionary measure, the chromatographic peaks in each window must not elute too close to the edge of the segment time window.

10.7 CONTINUING CALIBRATION CHECK (CCV) – Minimum daily calibration verification is as follows. Verify the initial calibration at the beginning and end of each group of analyses, and after every tenth sample during analyses. In this context, a “sample” is considered to be a Field Sample. MBs, CCVs, LCSs, MSs, FDs FRBs and MSDs are not counted as samples. The beginning CCV of each analysis batch must be at or below the RL in order to verify instrument sensitivity prior to any analyses. If standards have been prepared such that all low CAL points are not in the same CAL solution, it may be necessary to analyze two CAL standards to meet this requirement. Alternatively, the analyte concentrations in the analyte PDS may be customized to meet this criteria. Subsequent CCVs should alternate between a medium and high concentration CAL standard.

10.7.1 Inject an aliquot of the appropriate concentration CAL standard and analyze with the same conditions used during the initial calibration.

10.7.2 Determine that the absolute areas of the quantitation ions of the IS(s) are within 70-140% of the areas measured in the most recent continuing calibration check, and within 50-150% from the average areas measured during initial calibration. If any of the IS areas has changed by more than these amounts, adjustments must be made to restore system sensitivity. These adjustments may include cleaning of the MS ion source, or other maintenance as indicated in Section 10.7.4. Major instrument maintenance requires recalibration (Sect 10.6) and verification of sensitivity by analyzing a CCV at or below the RL (Sect 10.7). Control charts are useful aids in documenting system sensitivity changes.

10.7.3 Calculate the concentration of each analyte and SUR in the CCV. The calculated amount for each analyte and SUR for medium and high level CCVs must be within ± 30% of the true value. The calculated amount for the lowest calibration point for each analyte must be within ± 50% and the SUR must be within ± 30% of the true value. If these conditions do not exist, then all data for the problem analyte must be considered invalid, and remedial action should be taken (Sect. 10.7.4) which may require recalibration. Any Field or QC Samples that have been analyzed since the last acceptable calibration verification should be reanalyzed after adequate calibration has been restored, with the following exception. **If the CCV fails because the calculated concentration is greater than 130% (150% for the low-level CCV) for a particular method analyte, and Field Sample extracts show no detection for that method analyte, non-detects may be reported without re-analysis.**

10.7.4 REMEDIAL ACTION – Failure to meet CCV QC performance criteria may require remedial action. Major maintenance, such as cleaning the electrospray probe, atmospheric pressure ionization source, cleaning the mass analyzer, replacing the LC column, etc., requires recalibration (Sect 10.6) and verification of sensitivity by analyzing a CCV at or below the RL (Sect 10.7).

10.8 EXTRACT ANALYSIS

10.8.1 Establish operating conditions equivalent to those summarized in Tables 5-8 of Section 16. Instrument conditions and columns should be optimized prior to the initiation of the IDC.

10.8.2 Establish an appropriate retention time window for each analyte. This should be based on measurements of actual retention time variation for each method analyte in CAL standard solutions analyzed on the LC over the course of time. A value of plus or minus three times the standard deviation of the retention time obtained for each method analyte while establishing the initial calibration and completing the IDC can be used to calculate a suggested window size. However, the experience of the analyst should weigh heavily on the determination of the appropriate retention window size.

10.8.3 Calibrate the system by either the analysis of a calibration curve (Sect. 10.6) or by confirming the initial calibration is still valid by analyzing a CCV as described in Section 10.7. If establishing an initial calibration, complete the IDC as described in Section 13.2.

10.8.4 Begin analyzing Field Samples, including QC samples, at their appropriate frequency by injecting the same size aliquots (10 µL was used in method development), under the same conditions used to analyze the CAL standards.

10.8.5 At the conclusion of data acquisition, use the same software that was used in the calibration procedure to identify peaks of interest in predetermined retention time windows. Use the data system software to examine the ion abundances of the peaks in the chromatogram. Identify an analyte by comparison of its retention time with that of the corresponding method analyte peak in a reference standard.

10.8.6 Comparison of the MS/MS mass spectra is not particularly useful given the limited ±0.5 dalton mass range around a single product ion for each method analyte.

10.8.7 The analyst must not extrapolate beyond the established calibration range. If an analyte peak area exceeds the range of the initial calibration curve, the extract may be diluted with 96%:4% vol/vol) methanol:water solution and the appropriate amount of IS added to match the original concentration. Re-inject the diluted extract. Incorporate the dilution factor into the final concentration calculations. Acceptable SUR performance (Sect. 9.5.1.1) should be determined from the undiluted sample extract. The resulting data should be documented as a dilution, with an increased RL.

11. Data Evaluation, Calculations and Reporting

11.1 Complete chromatographic resolution is not necessary for accurate and precise measurements of analyte concentrations using MS/MS. In validating this method, concentrations were calculated by measuring the product ions listed in Table 8. Other ions may be selected at the discretion of the analyst.

11.2 Calculate analyte and SUR concentrations using the multipoint calibration established in Section 10.6. Do not use daily calibration verification data to quantitate analytes in samples. Adjust final analyte concentrations to reflect the actual sample volume determined in Section 10.5.

11.3 Prior to reporting the data, the chromatogram should be reviewed for any incorrect peak identification or poor integration.

11.4 PFHxS, PFOS, NMeFOSAA, and NEtFOSAA have multiple chromatographic peaks using the LC conditions in Table 5 due to the linear and branch isomers of these compounds (Sect. 10.6.4.1). The areas of all the linear and branched isomer peaks observed in the CAL standards for each of these analytes must be summed and the concentrations reported as a total for each of these analytes.

11.5 Calculations must utilize all available digits of precision, but final reported concentrations should be rounded to an appropriate number of significant figures (one digit of uncertainty), typically two, and not more than three significant figures.

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

12.1 Section 9.0 outlines sample batch QC acceptance criteria. If non-compliant organic compound results are to be reported, the Organic Section Head and/or the Laboratory Director, and the Operations Manager must approve the reporting of these results. The laboratory Project Manager shall be notified, and may choose to relay the non-compliance to the client, for approval, or other corrective action, such as re-sampling and re-analysis.

The analyst, Data Reviewer, or Department Supervisor performing the secondary review initiates the project narrative, and the narrative must clearly document the non-compliance and provide a reason for acceptance of these results.

12.2 All results for the organic compounds of interest are reportable without qualification if extraction and analytical holding times are met, preservation requirements (including cooler temperatures) are met, all QC criteria defined in the table below are met, and matrix interference is not suspected during extraction or analysis of the samples. If any of the below QC parameters are not met, all associated samples must be evaluated for re-extraction and/or re-analysis.

13. Method Performance

13.1 Detection Limit Study (DL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

13.1.1 The laboratory follows the procedure to determine the DL, LOD, and/or LOQ as outlined in Alpha SOP ID 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

13.2.1 The IDC must be successfully performed prior to analyzing any Field Samples. Prior to conducting the IDC, the analyst must first generate an acceptable Initial Calibration following the procedure outlined in Section 10.6.

13.2.2 INITIAL DEMONSTRATION OF LOW SYSTEM BACKGROUND – Any time a new lot of SPE cartridges, solvents, centrifuge tubes, disposable pipets, and autosampler vials are used, it must be demonstrated that an MB is reasonably free of contamination and that the criteria in Section 9.2.1 are met. If an automated extraction system is used, an MB should be extracted on each port to ensure that all the valves and tubing are free from potential PFAS contamination.

13.2.3 INITIAL DEMONSTRATION OF PRECISION (IDP) – Prepare, extract, and analyze four to seven replicate LCSs fortified near the midrange of the initial calibration curve according to the procedure described in Section 10. Sample preservatives as described in Section 6.2.1 must be added to these samples. The relative standard deviation (RSD) of the results of the replicate analyses must be less than 20%.

13.2.4 INITIAL DEMONSTRATION OF ACCURACY (IDA) – Using the same set of replicate data generated for Section 13.2.3, calculate average recovery. The average recovery of the replicate values must be within ± 30% of the true value.

13.2.5 INITIAL DEMONSTRATION OF PEAK ASYMMETRY FACTOR – Peak asymmetry factors must be calculated using the equation in Section 9.10.1 for the first two eluting peaks (if only two analytes are being analyzed, both must be evaluated) in a mid-level CAL standard. The peak asymmetry factors must fall in the range of 0.8 to 1.5. See guidance in Section 10.6.4.1 if the calculated peak asymmetry factors do not meet the criteria.

13.2.6 Refer to Alpha SOP ID 1739 for further information regarding IDC/DOC Generation.

13.2.7 The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

14.1.1 Refer to Alpha's Chemical Hygiene Plan and Hazardous Waste Management and Disposal SOP for further pollution prevention and waste management information.

14.1.2 This method utilizes SPE to extract analytes from water. It requires the use of very small volumes of organic solvent and very small quantities of pure analytes, thereby minimizing the potential hazards to both the analyst and the environment as compared to the use of large volumes of organic solvents in conventional liquid-liquid extractions.

14.1.3 The analytical procedures described in this method generate relatively small amounts of waste since only small amounts of reagents and solvents are used. The matrices of concern are finished drinking water or source water. However, laboratory waste management practices must be conducted consistent with all applicable rules and regulations, and that laboratories protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Also, compliance is required with any sewage discharge permits and regulations, particularly the hazardous waste identification rules and land disposal restrictions.

15. Referenced Documents

15.1.1 Chemical Hygiene Plan – ID 2124

15.1.2 SOP ID 1732 Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ) SOP

15.1.3 SOP ID 1739 Demonstration of Capability (DOC) Generation SOP

15.1.4 SOP ID 1728 Hazardous Waste Management and Disposal SOP

16. Attachments

Table 6: LC Method Conditions

Time (min)	% 20 mM Ammonium Acetate	% Methanol
Initial	60.0	40.0
1.0	60.0	40.0
25.0	10.0	90.0
32.0	10.0	90.0
32.1	60.0	40.0
37.0	60.0	40.0
Waters Atlantis ® dC_{18} 2.1 x 150 mm packed with 5.0 µm C_{18} stationary phase Flow rate of 0.3 mL/min 10 µL injection		

Table 7: ESI-MS Method Conditions

ESI Conditions	
Polarity	Negative ion
Capillary needle voltage	-3 kV
Cone Gas Flow	98 L/hr
Nitrogen desolvation gas	1100 L/hr
Desolvation gas temp.	350 ºC

Table 8: Method Analyte Source, Retention Times (RTs), and IS References

Analyte	Peak #	IS# Ref
PFBS	1	2
PFHxA	2	1
PFHpA	4	1
PFHxS	5	2
PFOA	6	1
PFNA	8	1
PFOS	9	2
PFDA	11	1
NMeFOSAA	13	3
NEtFOSAA	15	3
PFUnA	17	1
PFDoA	18	1
PFTrDA	19	1
PFTA	20	1
^{13}C-PFHxA	3	1
^{13}C-PFDA	12	1
d_5-NEtFOSAA	16	3
^{13}C-PFOA-IS#1	7	-
^{13}C-PFOS-IS#2	10	-
d_3-NMeFOSAA-IS#3	14	-

Table 9: MS/MS Method Conditions

Segment[a]	Analyte	Precursor Ion [b] (m/z)	Product Ion [b,c] (m/z)	Cone Voltage (v)	Collision Energy [d] (v)
1	PFBS	299	80	40	25
2	PFHxA	313	269	15	10
3	PFHpA	363	319	12	10
3	PFHxS [e]	399	80	40	40
4	PFOA	413	369	15	10
4	PFNA	463	419	12	10
4	PFOS [e]	499	80	40	40
5	PFDA	513	469	15	10
5	NMeFOSAA [e]	570	419	25	20
5	NEtFOSAA [e]	584	419	25	20
5	PFUnA	563	519	15	10
5	PFDoA	613	569	15	10
6	PFTrDA	663	619	15	10
6	PFTA	713	669	15	10
2	^{13}C-PFHxA	315	270	15	10
5	^{13}C-PFDA	515	470	12	12
5	d_5-NEtFOSAA	589	419	25	20
4	^{13}C-PFOA	415	370	15	10
4	^{13}C-PFOS	503	80	40	40
5	d_3-NMeFOSAA	573	419	25	20

[a] Segments are time durations in which single or multiple scan events occur.
[b] Precursor and product ions listed in this table are nominal masses. During MS and MS/MS optimization, the analyst should determine the precursor and product ion masses to one decimal place by locating the apex of the mass spectral peak place. These precursor and product ion masses (with one decimal place) should be used in the MS/MS method for all analyses.
[c] Ions used for quantitation purposes.
[d] Argon used as collision gas at a flow rate of 0.3 mL/min
[e] Analyte has multiple resolved chromatographic peaks due to linear and branched isomers. All peaks summed for quantitation purposes.

Table 10: Transition Ions

Compound	Precursor Ion (m/z)	Quant Ion (m/z)	Precursor formula	Primary Quant Ion formula	Cone Voltage (V)	Collision (eV)	2nd Qual Ion Mass (m/z)	2nd Qual Ion formula	Collision (eV)	Quant by:	Quantitation Reference
Native PFCs											
Perfluoorobutanoic acid	213	169	[CF3(CF2)2CO2]	[CF3(CF2)2]	27	8				ID	13CF3(13CF2)2 13COOH
Perfluoropentanoic acid	263	219	[CF3(CF2)3CO2]	[CF3(CF2)3]	27	8				IS	13CF3(13CF2)6 13COOH
Perfluoro-n-hexanoic acid	313	269	[CF3(CF2)4CO2]	[CF3(CF2)4]	27	20	119	[CF3CF2]	8	ID	CF3(CF2)3(13CF2)13COOH
Perfluoro-n-heptanoic acid	363	319	[CF3(CF2)5CO2]	[CF3(CF2)5]	27	12	169	[CF3(CF2)2]	8	IS	13CF3(13CF2)6 13COOH
Perfluoro-n-octanoic acid	413	369	[CF3(CF2)6CO2]	[CF3(CF2)6]	19	12	169	[CF3(CF2)2]	12	ID	CF3(CF2)3(13CF2)3 13COOH
Perfluoro-n-nonanoic acid	463	419	[CF3(CF2)7CO2]	[CF3(CF2)7]	20	13	219	[CF3(CF2)3]	12	ID	CF3(CF2)3(13CF2)4 13COOH
Perfluoro-n-decanoic acid	513	469	[CF3(CF2)8CO2]	[CF3(CF2)8]	21	11	219	[CF3(CF2)3]	13	ID	CF3(13CF2)8 13COOH
Perfluoro-n-undecanoic acid	563	519	[CF3(CF2)9CO2]	[CF3(CF2)9]	21	15	269	[CF3(CF2)4]	12	ID	CF3(13CF2)9COOH
Perfluoro-n-dodecanoic acid	613	569	[CF3(CF2)10CO2]	[CF3(CF2)10]	22	15	319	[CF3(CF2)5]	12	ID	CF3(CF2)9(13CF2)13COOH
Perfluoro-n-tridecanoic acid	663	619	[CF3(CF2)11CO2]	[CF3(CF2)11]	20	17	319	[CF3(CF2)5]	13	IS	13CF3(13CF2)6 13COOH
Perfluoro-n-tetradecanoic acid	713	669	[CF3(CF2)12CO2]	[CF3(CF2)12]	27	21	319	[CF3(CF2)5]	11	IS	13CF3(13CF2)6 13COOH
Perfluorobutanesulfonic acid	299	80	[CF3(CF2)3SO3]	[SO3]	70	40	99	[FSO3]	35	IS	13CF3(13CF2)6 13COOH
Perfluoro-n-hexane sulfonic acid 1	399	80	[CF3(CF2)5SO3]	[SO3]	30	45	99	[FSO3]	40	ID	CF3(CF2)5S(18O)2OH
Perfluoro-n-heptane sulfonic acid	449	80	[CF3(CF2)6SO3]	[SO3]	50	39	99	[FSO3]	38	IS	13CF3(13CF2)6 13COOH
Perfluoro-n-octanesulfonic acid	499	80	[CF3(CF2)7SO3]	[SO3]	80	45	99	[FSO3]	40	ID	CF3(CF2)3(13CF2)4SO3H
Perfluorooctane sulfonamide	498	78	[CF3(CF2)7SO2N H]	[SO2N]	80	40	478	[(CF2)8SO2N]	16	IS	13CF3(13CF2)6 13COOH
N-methylperfluoro-1-octanesulfonamide	512	169	[CF3(CF2)7SO2 N(CH3)]	[CF3(CF2)2]	27	45				IS	13CF3(13CF2)6 13COOH
N-ethylperfluoro-1-octanesulfonamide	526	169	[CF3(CF2)7SO2 N(C2H5)]	[CF3(CF2)2]	27	45				IS	13CF3(13CF2)6 13COOH
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	616	59	[CF3(CF2)7SO2N(CH3)C2H4OH·CH 3CO2]	[CH3CO2]	27	45				ID	CF3(CF2)7SO2N (CD3)C2D4OH·CH3COOH
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	630	59	[CF3(CF2)7SO2N(C2H5)C2H4OH·C H3CO2]	[CH3CO2]	27	45				IS	13CF3(13CF2)6 13COOH

Table 10: Transition Ions (continued)

Compound	Precursor Ion (m/z)	Quant Ion (m/z)	Precursor formula	Primary Quant Ion formula	Cone Voltage (V)	Collision (eV)	2nd Qual Ion Mass (m/z)	2nd Qual Ion formula	Collision (eV)	Quant by:	Quantitation Reference
Mass-labeled PFCs											
Perfluoro-n-[1,2,3,413C4]butanoic acid	217	172	[13CF3(13CF2)2 13CO2]	[13CF3(13CF2)2]	27	8				IS	13CF3(13CF2)6 13COOH
Perfluoro-n-[1,213C2]hexanoic acid	315	270	[CF3(CF2)3(13CF2)13CO2]	[CF3(CF2)3(13C F 2)]	27	8				IS	13CF3(13CF2)6 13COOH
Perfluoro-n-[1,2,3,413 C4]octanoic acid	417	372	[CF3(CF2)3 (13CF2)3 13CO2]	[CF3(CF2)3 (13CF2)3]	21	12				IS	13CF3(13CF2)6 13COOH
Perfluoro-n-[1,2,3,4,513 C5]nonanoic acid	468	423	[CF3(CF2)3 (13CF2)4 13CO2]	[CF3(CF2)3(13C F 2)4]	20	12				IS	13CF3(13CF2)6 13COOH
Perfluoro-n-[1,213C2]decanoic acid	515	470	[CF3(CF2)7(13CF2)13CO2]	[CF3(CF2)2(13C F 2)]	21	12				IS	13CF3(13CF2)6 13COOH
Perfluoro-n[1,2,3,4,5,6,7,8,9-13C9]decanoic acid	522	477	[CF3(13CF2)8 13CO2]	[CF3(13CF2)8]	20	12				IS	13CF3(13CF2)6 13COOH
Perfluoro-n-[1,213C2]undecanoic acid	565	520	[CF3(CF2)8(13CF2)13CO2]	[CF3(CF2)8(13C F 2)]	20	12				IS	13CF3(13CF2)6 13COOH
Perfluoro-n[2,3,4,5,6,7,8,9,10-13C9]undecanoic acid	572	528	[CF3(13CF2)9CO2]	[CF3(13CF2)9]	20	12				IS	13CF3(13CF2)6 13COOH
Perfluoro-n-[1,213C2]dodecanoic acid	615	570	[CF3(CF2)9 (13CF2)13CO2]	[CF3(CF2)9 (13CF2)]	22	12				IS	13CF3(13CF2)6 13COOH
Perfluoro-1-[1,218 O2]-hexanesulfonic acid	403	84	[CF3(CF2)5 S(18O)2O]	[S(18O)2O]	30	45	103	[FS(18O)2 O]	45	IS	13CF3(13CF2)6 13COOH
Perfluoro-n-[1,2,3,413 C4]-octanesulfonate	503	80	[CF3(CF2)3 (13CF2)4SO3]	[SO3]	40	45	99	[FSO3]	40	IS	13CF3(13CF2)6 13COOH
2-(Ndeuteriomethylperfluoro-1-octanesulfonamido)1,1,2,2-tetradeuterioethanol	623	59	[CF3(CF2)7SO2N (CD3)C2D4OH·C H3CO2]	[CH3CO2]	27	45				IS	13CF3(13CF2)6 13COOH
Injection Internal Standards (compound added after extraction, but prior to injection)											
Perfluoro-n[1,2,3,4,5,6,7,8-13 C8]octanoic acid	421	376	[13CF3(13CF2)6 13CO2]	[13CF3(3CF2)6]	21	12				ES	
2H-Perfluoro-[1,213C2]-2decenoic acid	459	394	[CF3(CF2)6 CF13CH13CO2]	[CF3(CF2)3 (13CF2)3]	21	11				ES	

Standard Operating Procedure **ASTM D422**

Technical Information

Reference Number:	ASTM D422-07
Test Method Title:	Test Method for Particle Size Analysis of Soils
Test Property:	Grain Size Analysis
Test Specimen Size:	Passing #10 sieve: 115 g sandy soils, 65 g silty or clayey soils Retained on #10 sieve: see test standard (based on largest particle size)
Number of Test Specimens:	1 representative sample obtained by quartering, mixing or splitting
Test Equipment:	Hydrometer (ASTM) Sedimentation Cylinder Stirring Apparatus (blender) Dispersion Cup Drying containers Balance readable to 0.01 gram for material passing #10 sieve or 0.1% of mass for material retained on #10 sieve Thermometer readable to 0.5 ºC Various sieves 250 mL beaker Drying oven capable of maintaining a temperature of 110 ± 5 ºC Dispersing agent mixture (40 g/L of Sodium Hexametaphosphate solution) Mechanical sieve shaker Distilled Water Spray Bottle Wash pan

Standard Operating Procedure

Sampling

1. Collect a representative sample and perform a moisture content test in accordance with ASTM D 2216.

2. Collect another representative sample to be used for the particle size analysis. Base specimen size on test standard (based on largest particle size). Record specimen wet weight.

Splitting / Washing sample on #200 sieve

3. Add 125 ml of dispersing agent into sample container. Stir well and allow to soak for at least 16 hours.

4. Rinse sample into dispersion cup and use stirring apparatus (blender) to further disperse sample for 1 minute.

5. Wash the test specimen from the dispersion cup, using distilled water, over the No. 200 sieve into a container. Be sure to collect all washings in the container. Use only 800 ml of distilled water for the washing operation.

6. Transfer the portion retained on the No. 200 into a tare and place in a drying oven.

7. Wash the minus No. 200 sieve material into a Sedimentation cylinder.

Sieve analysis of portion retained on #200 sieve

8. Separate the portion retained on #200 sieve into a series of fractions using various sieve sizes ranging from 3 inch to #200. Set up in mechanical shaker and shake for 10 minutes. Determine the mass retained on each sieve by weighing and recording mass to nearest 0.1 % of sample mass.

Hydrometer analysis of portion passing #200 sieve

9. Add distilled water to the1000 mL point. Place a rubber stopper over the open end and turn the cylinder upside down and back for a period of 1 minute (should be 60 turns per minute). Set the cylinder down, remove stopper and wash any adhering soil into the cylinder. Begin to take and record hydrometer readings at the following intervals: 2, 5, 15, 30, 60, 120, 240, and approximately 1440 minutes. After each reading, the temperature of the solution should be recorded.

10. Calculations: Use initial moisture content and initial wet weight of test specimen to calculate initial dry weight of test specimen. Use reporting software to enter data and calculate % passing and retained for each sieve size and hydrometer readings.

11. Report: sample identification, sample description, percentage passing or retained on each sieve fraction (tabular and graphical).

ATTACHMENT C
Laboratory Certifications

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

TestAmerica Sacramento
880 Riverside Parkway
West Sacramento, CA 95605

has been assessed by ANAB
and meets the requirements of international standard

ISO/IEC 17025:2005

and DoD Quality Systems Manual for Environmental Laboratories (DoD QSM V 5.1)

while demonstrating technical competence in the fields of

TESTING

Refer to the accompanying Scope of Accreditation for information regarding the types of calibrations and/or tests to which this accreditation applies.

L2468
Certificate Number

ANAB Approval

Certificate Valid: 01/17/2018-01/20/2021
Version No. 001 Issued: 01/17/2018

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

ANSI-ASQ National Accreditation Board

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 AND DOD QUALITY SYSTEMS MAUAL FOR ENVIRONMENTAL LABORATORIES (DOD QSM V5.1)

TestAmerica Sacramento
880 Riverside Parkway
West Sacramento, CA 95605
Ms. Lisa Stafford
916-373-5600

TESTING

Valid to: **January 20, 2021** Certificate Number: **L2468**

Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/6010C	Aluminum
ICP-AES	EPA 6010B/6010C	Antimony
ICP-AES	EPA 6010B/6010C	Arsenic
ICP-AES	EPA 6010B/6010C	Barium
ICP-AES	EPA 6010B/6010C	Beryllium
ICP-AES	EPA 6010B/6010C	Boron
ICP-AES	EPA 6010B/6010C	Cadmium
ICP-AES	EPA 6010B/6010C	Calcium
ICP-AES	EPA 6010B/6010C	Chromium (Total)
ICP-AES	EPA 6010B/6010C	Cobalt
ICP-AES	EPA 6010B/6010C	Copper
ICP-AES	EPA 6010B/6010C	Iron
ICP-AES	EPA 6010B/6010C	Lead
ICP-AES	EPA 6010B/6010C	Magnesium
ICP-AES	EPA 6010B/6010C	Manganese
ICP-AES	EPA 6010B/6010C	Molybdenum
ICP-AES	EPA 6010B/6010C	Nickel
ICP-AES	EPA 6010B/6010C	Potassium
ICP-AES	EPA 6010B/6010C	Selenium
ICP-AES	EPA 6010B/6010C	Silica

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/6010C	Silicon
ICP-AES	EPA 6010B/6010C	Silver
ICP-AES	EPA 6010B/6010C	Sodium
ICP-AES	EPA 6010B/6010C	Thallium
ICP-AES	EPA 6010B/6010C	Tin
ICP-AES	EPA 6010B/6010C	Titanium
ICP-AES	EPA 6010B/6010C	Vanadium
ICP-AES	EPA 6010B/6010C	Zinc
ICP-MS	EPA 6020/6020A	Aluminum
ICP-MS	EPA 6020/6020A	Antimony
ICP-MS	EPA 6020/6020A	Arsenic
ICP-MS	EPA 6020/6020A	Barium
ICP-MS	EPA 6020/6020A	Beryllium
ICP-MS	EPA 6020/6020A	Cadmium
ICP-MS	EPA 6020/6020A	Calcium
ICP-MS	EPA 6020/6020A	Chromium (Total)
ICP-MS	EPA 6020/6020A	Cobalt
ICP-MS	EPA 6020/6020A	Copper
ICP-MS	EPA 6020/6020A	Iron
ICP-MS	EPA 6020/6020A	Lead
ICP-MS	EPA 6020/6020A	Magnesium
ICP-MS	EPA 6020/6020A	Manganese
ICP-MS	EPA 6020/6020A	Molybdenum
ICP-MS	EPA 6020/6020A	Nickel
ICP-MS	EPA 6020/6020A	Phosphorus
ICP-MS	EPA 6020/6020A	Potassium
ICP-MS	EPA 6020/6020A	Selenium
ICP-MS	EPA 6020/6020A	Silver
ICP-MS	EPA 6020/6020A	Sodium
ICP-MS	EPA 6020/6020A	Strontium
ICP-MS	EPA 6020/6020A	Thallium
ICP-MS	EPA 6020/6020A	Tin
ICP-MS	EPA 6020/6020A	Titanium
ICP-MS	EPA 6020/6020A	Uranium
ICP-MS	EPA 6020/6020A	Vanadium
ICP-MS	EPA 6020/6020A	Zinc

Non-Potable Water		
Technology	**Method**	**Analyte**
CVAAS	EPA 7470A	Mercury
Colorimetric	EPA 353.2	Nitrate
Colorimetric	EPA 353.2	Nitrate-nitrite
Colorimetric	EPA 353.2	Nitrite
Colorimetric	EPA 410.4	Chemical Oxygen Demand (COD)
LC/MS/MS	EPA 6850	Perchlorate
Colorimetric	EPA 7196A	Chromium (Hexavalent)
Probe	EPA 9040B/9040C	pH
Ion Chromatography	EPA 9056A/300.0	Bromide
Ion Chromatography	EPA 9056A/300.0	Chloride
Ion Chromatography	EPA 9056A/300.0	Fluoride
Ion Chromatography	EPA 9056A/300.0	Nitrate
Ion Chromatography	EPA 9056A/300.0	Nitrite
Ion Chromatography	EPA 9056A/300.0	Orthophosphate
Ion Chromatography	EPA 9056A/300.0	Sulfate
Titration	SM 2320B	Alkalinity
Gravimetric	SM 2540B	Solids, Total
Gravimetric	SM 2540C	Solids, Total Dissolved
Gravimetric	SM 2540D	Solids, Total Suspended
Colorimetric/Hydrolysis	EPA 353.2 Modified / WS-WC-0050	Nitrocellulose
GC/MS	EPA 8260B/8260C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C	1,1,1-Trichloroethane
GC/MS	EPA 8260B/8260C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C	1,1,2-Trichloroethane
GC/MS	EPA 8260B/8260C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 8260B/8260C	1,1-Dichloroethane
GC/MS	EPA 8260B/8260C	1,1-Dichloroethene
GC/MS	EPA 8260B/8260C	1,1-Dichloropropene
GC/MS	EPA 8260B/8260C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/8260C	1,2,3-Trichloropropane
GC/MS	EPA 8260B/8260C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/8260C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/8260C	1,2-Dibromo-3-chloropropane
GC/MS	EPA 8260B/8260C	1,2-Dibromoethane
GC/MS	EPA 8260B/8260C	1,2-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1,2-Dichloroethane

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C	1,2-Dichloropropane
GC/MS	EPA 8260B/8260C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/8260C	1,3-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1,3-Dichloropropane
GC/MS	EPA 8260B/8260C	1,4-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1-Chlorohexane
GC/MS	EPA 8260B/8260C	2,2-Dichloropropane
GC/MS	EPA 8260B/8260C	2-Butanone (MEK)
GC/MS	EPA 8260B/8260C	2-Chlorotoluene
GC/MS	EPA 8260B/8260C	2-Hexanone (MBK)
GC/MS	EPA 8260B/8260C	2-Methyl-2-propanol (tert- Butyl Alcohol, TBA)
GC/MS	EPA 8260B/8260C	4-Chlorotoluene
GC/MS	EPA 8260B/8260C	4-Isopropyltoluene
GC/MS	EPA 8260B/8260C	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA 8260B/8260C	Acetone
GC/MS	EPA 8260B/8260C	Allyl Chloride
GC/MS	EPA 8260B/8260C	Benzene
GC/MS	EPA 8260B/8260C	Bromobenzene
GC/MS	EPA 8260B/8260C	Bromochloromethane
GC/MS	EPA 8260B/8260C	Bromodichloromethane
GC/MS	EPA 8260B/8260C	Bromoform
GC/MS	EPA 8260B/8260C	Bromomethane
GC/MS	EPA 8260B/8260C	Carbon Disulfide
GC/MS	EPA 8260B/8260C	Carbon Tetrachloride
GC/MS	EPA 8260B/8260C	Chlorobenzene
GC/MS	EPA 8260B/8260C	Chloroethane
GC/MS	EPA 8260B/8260C	Chloroform
GC/MS	EPA 8260B/8260C	Chloromethane
GC/MS	EPA 8260B/8260C	cis-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C	Cyclohexane
GC/MS	EPA 8260B/8260C	Dibromochloromethane
GC/MS	EPA 8260B/8260C	Dibromomethane
GC/MS	EPA 8260B/8260C	Dichlorodifluoromethane
GC/MS	EPA 8260B/8260C	Diisopropyl Ether (DIPE)
GC/MS	EPA 8260B/8260C	Ethylbenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C	Ethylmethacrylate
GC/MS	EPA 8260B/8260C	Ethyl tert-butyl Ether (ETBE)
GC/MS	EPA 8260B/8260C	Hexachlorobutadiene
GC/MS	EPA 8260B/8260C	Hexane
GC/MS	EPA 8260B/8260C	Iodomethane
GC/MS	EPA 8260B/8260C	Isobutanol (2-Methyl-1-propanol)
GC/MS	EPA 8260B/8260C	Isopropylbenzene
GC/MS	EPA 8260B/8260C	m & p Xylene
GC/MS	EPA 8260B/8260C	Methyl tert-butyl Ether (MTBE)
GC/MS	EPA 8260B/8260C	Methylene Chloride
GC/MS	EPA 8260B/8260C	Naphthalene
GC/MS	EPA 8260B/8260C	n-Butylbenzene
GC/MS	EPA 8260B/8260C	n-Propylbenzene
GC/MS	EPA 8260B/8260C	o-Xylene
GC/MS	EPA 8260B/8260C	sec-Butylbenzene
GC/MS	EPA 8260B/8260C	Styrene
GC/MS	EPA 8260B/8260C	t-Amyl methyl Ether (TAME)
GC/MS	EPA 8260B/8260C	t-1,4-Dichloro-2-Butene
GC/MS	EPA 8260B/8260C	tert-Butylbenzene
GC/MS	EPA 8260B/8260C	Tetrachloroethene
GC/MS	EPA 8260B/8260C	Toluene
GC/MS	EPA 8260B/8260C	trans-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C	trans-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C	Trichloroethene
GC/MS	EPA 8260B/8260C	Trichlorofluoromethane
GC/MS	EPA 8260B/8260C	Vinyl Acetate
GC/MS	EPA 8260B/8260C	Vinyl Chloride
GC/MS	EPA 8260B/8260C	Xylenes, Total
GC/MS	EPA 8260B/AK101MS	Gasoline (GRO)
GC/MS	EPA 8270C/8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/8270D	1,2-Dichlorobenzene
GC/MS	EPA 8270C/8270D	1,2-Diphenylhydrazine (as Azobenzene)
GC/MS	EPA 8270C/8270D	1,3-Dichlorobenzene
GC/MS	EPA 8270C/8270D	1,3-Dinitrobenzene
GC/MS	EPA 8270C/8270D	1,4-Dichlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D	1-Methylnaphthalene
GC/MS	EPA 8270C/8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270C/8270D	2,4-Dichlorophenol
GC/MS	EPA 8270C/8270D	2,4-Dimethylphenol
GC/MS	EPA 8270C/8270D	2,4-Dinitrophenol
GC/MS	EPA 8270C/8270D	2,4-Dinitrotoluene
GC/MS	EPA 8270C/8270D	2,6-Dichlorophenol
GC/MS	EPA 8270C/8270D	2,6-Dinitrotoluene
GC/MS	EPA 8270C/8270D	2-Chloronaphthalene
GC/MS	EPA 8270C/8270D	2-Chlorophenol
GC/MS	EPA 8270C/8270D	2-Methylnaphthalene
GC/MS	EPA 8270C/8270D	2-Methylphenol
GC/MS	EPA 8270C/8270D	2-Nitroaniline
GC/MS	EPA 8270C/8270D	2-Nitrophenol
GC/MS	EPA 8270C/8270D	3&4-Methylphenol
GC/MS	EPA 8270C/8270D	3,3'-Dichlorobenzidine
GC/MS	EPA 8270C/8270D	3-Nitroaniline
GC/MS	EPA 8270C/8270D	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270C/8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/8270D	4-Chloroaniline
GC/MS	EPA 8270C/8270D	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/8270D	4-Nitroaniline
GC/MS	EPA 8270C/8270D	4-Nitrophenol
GC/MS	EPA 8270C/8270D	Acenaphthene
GC/MS	EPA 8270C/8270D	Acenaphthylene
GC/MS	EPA 8270C/8270D	Aniline
GC/MS	EPA 8270C/8270D	Anthracene
GC/MS	EPA 8270C/8270D	Benzo(a)anthracene
GC/MS	EPA 8270C/8270D	Benzo(a)pyrene
GC/MS	EPA 8270C/8270D	Benzo(b)fluoranthene
GC/MS	EPA 8270C/8270D	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/8270D	Benzo(k)fluoranthene
GC/MS	EPA 8270C/8270D	Benzoic Acid

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D	Benzyl Alcohol
GC/MS	EPA 8270C/8270D	Benzyl butyl Phthalate
GC/MS	EPA 8270C/8270D	Biphenyl
GC/MS	EPA 8270C/8270D	Bis(2-chloroethoxy) Methane
GC/MS	EPA 8270C/8270D	Bis(2-chloroethyl) Ether
GC/MS	EPA 8270C/8270D	Bis(2-chloroisopropyl) Ether
GC/MS	EPA 8270C/8270D	Carbazole
GC/MS	EPA 8270C/8270D	Chrysene
GC/MS	EPA 8270C/8270D	Bis (2-ethylhexyl) Phthalate
GC/MS	EPA 8270C/8270D	Dibenz(a,h)anthracene
GC/MS	EPA 8270C/8270D	Dibenzofuran
GC/MS	EPA 8270C/8270D	Diethyl Phthalate
GC/MS	EPA 8270C/8270D	Dimethyl Phthalate
GC/MS	EPA 8270C/8270D	Di-n-butyl Phthalate
GC/MS	EPA 8270C/8270D	Di-n-octyl Phthalate
GC/MS	EPA 8270C/8270D	Fluoranthene
GC/MS	EPA 8270C/8270D	Fluorene
GC/MS	EPA 8270C/8270D	Hexachlorobenzene
GC/MS	EPA 8270C/8270D	Hexachlorobutadiene
GC/MS	EPA 8270C/8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270C/8270D	Hexachloroethane
GC/MS	EPA 8270C/8270D	Indeno(1,2,3-c,d) Pyrene
GC/MS	EPA 8270C/8270D	Isophorone
GC/MS	EPA 8270C/8270D	Naphthalene
GC/MS	EPA 8270C/8270D	Nitrobenzene
GC/MS	EPA 8270C/8270D	n-Nitrosodimethylamine
GC/MS	EPA 8270C/8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270C/8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270C/8270D	Pentachlorophenol
GC/MS	EPA 8270C/8270D	Phenanthrene
GC/MS	EPA 8270C/8270D	Phenol
GC/MS	EPA 8270C/8270D	Pyrene
GC/MS	EPA 8270C/8270D	Pyridine
GC/MS SIM	EPA 8260C-SIM	1,1,2-Trichloroethane
GC/MS SIM	EPA 8260C-SIM	1,1,2,2-Tetrachloroethane
GC/MS SIM	EPA 8260C-SIM	1,2,3-Trichloropropane

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8260C-SIM	1,2-Dibromoethane
GC/MS SIM	EPA 8260C-SIM	1,2-Dichloroethane
GC/MS SIM	EPA 8260C-SIM	1,3-Butadiene
GC/MS SIM	EPA 8260C-SIM	1,4-Dichlorobenzene
GC/MS SIM	EPA 8260C-SIM	Benzene
GC/MS SIM	EPA 8260C-SIM	Bromodichloromethane
GC/MS SIM	EPA 8260C-SIM	Bromoform
GC/MS SIM	EPA 8260C-SIM	Bromomethane
GC/MS SIM	EPA 8260C-SIM	Chloroform
GC/MS SIM	EPA 8260C-SIM	Dibromochloromethane
GC/MS SIM	EPA 8260C-SIM	Hexachlorobutadiene
GC/MS SIM	EPA 8260C-SIM	Naphthalene
GC/MS SIM	EPA 8260C-SIM	Tetrachloroethene
GC/MS SIM	EPA 8260C-SIM	Trichloroethene
GC/MS SIM	EPA 8260C-SIM	Vinyl Chloride
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	1-Methylnaphthalene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	2-Methylnaphthalene
GC/MS SIM	EPA 8270D-SIM	3,3'-Dichlorobenzidine
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Acenaphthene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Acenaphthylene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Anthracene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(a)anthracene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(a)pyrene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(b)fluoranthene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(g,h,i)perylene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(k)fluoranthene
GC/MS SIM	EPA 8270D-SIM	Bis(2-chloroethyl) Ether
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Chrysene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Dibenz(a,h)anthracene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Fluoranthene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Fluorene
GC/MS SIM	EPA 8270D-SIM	Hexachlorobenzene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Indeno(1,2,3-c,d) Pyrene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Naphthalene
GC/MS SIM	EPA 8270D-SIM	n-Nitrosodimethylamine
GC/MS SIM	EPA 8270D-SIM	n-Nitrosodi-n-propylamine
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Phenanthrene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Pyrene
GC/MS SIM	EPA 8270C-SIM Modified / WS-MS-0011	1,4-Dioxane
GC-IT/MS	EPA 521 Modified / WS-MS-0012	N-Nitrosodimethyl amine (NDMA)
GC-FID	EPA 8015B/8015C/8015D AK102	Diesel Range Organics (DRO)
GC-FID	AK103	Residual Range Organics
GC-FID	EPA 8015B/8015C/8015D	Motor Oil Range Organics (MRO)
GC-ECD	EPA 8081A/8081B	Aldrin
GC-ECD	EPA 8081A/8081B	a-BHC
GC-ECD	EPA 8081A/8081B	b-BHC
GC-ECD	EPA 8081A/8081B	d-BHC
GC-ECD	EPA 8081A/8081B	g-BHC (Lindane)
GC-ECD	EPA 8081A/8081B	a-Chlordane
GC-ECD	EPA 8081A/8081B	g-Chlordane
GC-ECD	EPA 8081A/8081B	4,4'-DDD
GC-ECD	EPA 8081A/8081B	4,4'-DDE
GC-ECD	EPA 8081A/8081B	4,4'-DDT
GC-ECD	EPA 8081A/8081B	Dieldrin
GC-ECD	EPA 8081A/8081B	Endosulfan I
GC-ECD	EPA 8081A/8081B	Endosulfan II
GC-ECD	EPA 8081A/8081B	Endosulfan sulfate

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-ECD	EPA 8081A/8081B	Endrin
GC-ECD	EPA 8081A/8081B	Endrin Aldehyde
GC-ECD	EPA 8081A/8081B	Endrin Ketone
GC-ECD	EPA 8081A/8081B	Heptachlor
GC-ECD	EPA 8081A/8081B	Heptachlor Epoxide
GC-ECD	EPA 8081A/8081B	Methoxychlor
GC-ECD	EPA 8081A/8081B	Toxaphene
GC-ECD	EPA 8081A/8081B	Chlordane (technical)
GC-ECD	EPA 8082/8082A	PCB-1016
GC-ECD	EPA 8082/8082A	PCB-1221
GC-ECD	EPA 8082/8082A	PCB-1232
GC-ECD	EPA 8082/8082A	PCB-1242
GC-ECD	EPA 8082/8082A	PCB-1248
GC-ECD	EPA 8082/8082A	PCB-1254
GC-ECD	EPA 8082/8082A	PCB-1260
GC-ECD	EPA 8082/8082A	PCB-1262
GC-ECD	EPA 8082/8082A	PCB-1268
GC/MS	EPA 8280A/8280B	2,3,7,8-TeCDD
GC/MS	EPA 8280A/8280B	1,2,3,7,8-PeCDD
GC/MS	EPA 8280A/8280B	1,2,3,4,7,8-HxCDD
GC/MS	EPA 8280A/8280B	1,2,3,6,7,8-HxCDD
GC/MS	EPA 8280A/8280B	1,2,3,7,8,9-HxCDD
GC/MS	EPA 8280A/8280B	1,2,3,4,6,7,8-HpCDD
GC/MS	EPA 8280A/8280B	OCDD
GC/MS	EPA 8280A/8280B	2,3,7,8-TeCDF
GC/MS	EPA 8280A/8280B	1,2,3,7,8-PeCDF
GC/MS	EPA 8280A/8280B	2,3,4,7,8-PeCDF
GC/MS	EPA 8280A/8280B	1,2,3,4,7,8-HxCDF
GC/MS	EPA 8280A/8280B	1,2,3,6,7,8-HxCDF
GC/MS	EPA 8280A/8280B	1,2,3,7,8,9-HxCDF
GC/MS	EPA 8280A/8280B	2,3,4,6,7,8-HxCDF
GC/MS	EPA 8280A/8280B	1,2,3,4,6,7,8-HpCDF
GC/MS	EPA 8280A/8280B	1,2,3,4,7,8,9-HpCDF
GC/MS	EPA 8280A/8280B	OCDF
GC/MS	EPA 8280A/8280B	Total TCDD
GC/MS	EPA 8280A/8280B	Total PeCDD

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8280A/8280B	Total HxCDD
GC/MS	EPA 8280A/8280B	Total HeptaCDD
GC/MS	EPA 8280A/8280B	Total TCDF
GC/MS	EPA 8280A/8280B	Total PeCDF
GC/MS	EPA 8280A/8280B	Total HxCDF
GC/MS	EPA 8280A/8280B	Total HpCDF
GC/HRMS	EPA 8290/8290A/1613B	2,3,7,8-TeCDD
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,7,8-PeCDD
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,4,7,8-HxCDD
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,6,7,8-HxCDD
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,7,8,9-HxCDD
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,4,6,7,8-HpCDD
GC/HRMS	EPA 8290/8290A/1613B	OCDD
GC/HRMS	EPA 8290/8290A/1613B	2,3,7,8-TeCDF
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,7,8-PeCDF
GC/HRMS	EPA 8290/8290A/1613B	2,3,4,7,8-PeCDF
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,4,7,8-HxCDF
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,6,7,8-HxCDF
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,7,8,9-HxCDF
GC/HRMS	EPA 8290/8290A/1613B	2,3,4,6,7,8-HxCDF
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,4,6,7,8-HpCDF
GC/HRMS	EPA 8290/8290A/1613B	1,2,3,4,7,8,9-HpCDF
GC/HRMS	EPA 8290/8290A/1613B	OCDF
GC/HRMS	EPA 8290/8290A/1613B	Total TCDD
GC/HRMS	EPA 8290/8290A/1613B	Total PeCDD
GC/HRMS	EPA 8290/8290A/1613B	Total HxCDD
GC/HRMS	EPA 8290/8290A/1613B	Total HpCDD
GC/HRMS	EPA 8290/8290A/1613B	Total TCDF
GC/HRMS	EPA 8290/8290A/1613B	Total PeCDF
GC/HRMS	EPA 8290/8290A/1613B	Total HxCDF
GC/HRMS	EPA 8290/8290A/1613B	Total HpCDF
HPLC/UV	EPA 8330A/8330B	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330A/8330B	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330A/8330B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/8330B	1,3-Dinitrobenzene
HPLC/UV	EPA 8330A/8330B	2,4-Dinitrotoluene

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC/UV	EPA 8330A/8330B	2,6-Dinitrotoluene
HPLC/UV	EPA 8330A/8330B	Glycerol trinitrate (Nitroglycerin)
HPLC/UV	EPA 8330A/8330B	Hexahydro-1,3,5-trinitro- 1,3,5-triazine (Hexogen)
HPLC/UV	EPA 8330A/8330B	Methyl-2,4,6- trinitrophenylnitramine
HPLC/UV	EPA 8330A/8330B	Nitrobenzene
HPLC/UV	EPA 8330A/8330B	2-Nitrotoluene (o-Nitrotoluene)
HPLC/UV	EPA 8330A/8330B	3-Nitrotoluene (m-Nitrotoluene)
HPLC/UV	EPA 8330A/8330B	4-Nitrotoluene (p-Nitrotoluene)
HPLC/UV	EPA 8330A/8330B	Octahydro-1,3,5,7- tetranitro1,3,5,7-tetracine (Octogen)
HPLC/UV	EPA 8330A/8330B	Picric acid
HPLC/UV	EPA 8330A/8330B	Pentaerythritol Tetranitrate
HPLC/UV	EPA 8330A/8330B	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330A/8330B	2,4,6-Trinitrotoluene
HPLC/UV	EPA 8330A/8330B	Hexahydro-1,3-dinitroso-5- nitro-1,3,5,triazine (DNX)
HPLC/UV	EPA 8330A/8330B	Hexahydro-1,3,5-trinitroso- 1,3,5-triazine (TNX)
HPLC/UV	EPA 8330A/8330B	1-Nitroso-3,5-dinitro-1,3,5- triazacyclohexane (MNX)
HPLC/UV	EPA 8330A Modified /WS-LC-0010	Nitroguanidine
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	6:2 Fluorotelomer sulfonate (6:2 FTS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	8:2 Fluorotelomer sulfonate (8:2 FTS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	N-Ethyl perfluorooctanesulfon amidacetic acid (EtFOSAA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	N-Methyl perfluorooctanesulfon amidoacetic acid (MeFOSAA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorooctanoic acid (PFOA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorooctane Sulfonic Acid (PFOS)

Non-Potable Water		
Technology	**Method**	**Analyte**
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorobutyric acid (PFBA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoropentanoic acid (PFPA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorohexanoic acid (PFHxA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoroheptanoic acid (PFHpA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorononanoic acid (PFNA)
LC/MS/MS	EPA 537 Modified / WS-LC-0025	Perfluorodecanoic acid (PFDA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoroundecanoic acid (PFUDA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorododecanoic acid (PFDoDA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorotridecanoic acid (PFTriA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorotetradecanoic acid (PDTeA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorobutane Sulfonic Acid (PFBS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorohexane Sulfonic Acid (PFHxS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoroheptane Sulfonic Acid (PFHpS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorodecane Sulfonic Acid (PFDS)

Non-Potable Water		
Technology	**Method**	**Analyte**
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoroocatane Sulfonamide (FOSA)
GC/HRMS	EPA 1668A/1668C	PCB 1
GC/HRMS	EPA 1668A/1668C	PCB 2
GC/HRMS	EPA 1668A/1668C	PCB 3
GC/HRMS	EPA 1668A/1668C	PCB 4
GC/HRMS	EPA 1668A/1668C	PCB 5
GC/HRMS	EPA 1668A/1668C	PCB 6
GC/HRMS	EPA 1668A/1668C	PCB 7
GC/HRMS	EPA 1668A/1668C	PCB 8
GC/HRMS	EPA 1668A/1668C	PCB 9
GC/HRMS	EPA 1668A/1668C	PCB 10
GC/HRMS	EPA 1668A/1668C	PCB 11
GC/HRMS	EPA 1668A/1668C	PCB 12
GC/HRMS	EPA 1668A/1668C	PCB 13
GC/HRMS	EPA 1668A/1668C	PCB 14
GC/HRMS	EPA 1668A/1668C	PCB 15
GC/HRMS	EPA 1668A/1668C	PCB 16
GC/HRMS	EPA 1668A/1668C	PCB 17
GC/HRMS	EPA 1668A/1668C	PCB 18
GC/HRMS	EPA 1668A/1668C	PCB 19
GC/HRMS	EPA 1668A/1668C	PCB 20
GC/HRMS	EPA 1668A/1668C	PCB 21
GC/HRMS	EPA 1668A/1668C	PCB 22
GC/HRMS	EPA 1668A/1668C	PCB 23
GC/HRMS	EPA 1668A/1668C	PCB 24
GC/HRMS	EPA 1668A/1668C	PCB 25
GC/HRMS	EPA 1668A/1668C	PCB 26
GC/HRMS	EPA 1668A/1668C	PCB 27
GC/HRMS	EPA 1668A/1668C	PCB 28
GC/HRMS	EPA 1668A/1668C	PCB 29
GC/HRMS	EPA 1668A/1668C	PCB 30
GC/HRMS	EPA 1668A/1668C	PCB 32
GC/HRMS	EPA 1668A/1668C	PCB 31
GC/HRMS	EPA 1668A/1668C	PCB 33
GC/HRMS	EPA 1668A/1668C	PCB 34

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 35
GC/HRMS	EPA 1668A/1668C	PCB 36
GC/HRMS	EPA 1668A/1668C	PCB 37
GC/HRMS	EPA 1668A/1668C	PCB 38
GC/HRMS	EPA 1668A/1668C	PCB 39
GC/HRMS	EPA 1668A/1668C	PCB 40
GC/HRMS	EPA 1668A/1668C	PCB 41
GC/HRMS	EPA 1668A/1668C	PCB 42
GC/HRMS	EPA 1668A/1668C	PCB 43
GC/HRMS	EPA 1668A/1668C	PCB 44
GC/HRMS	EPA 1668A/1668C	PCB 45
GC/HRMS	EPA 1668A/1668C	PCB 46
GC/HRMS	EPA 1668A/1668C	PCB 47
GC/HRMS	EPA 1668A/1668C	PCB 48
GC/HRMS	EPA 1668A/1668C	PCB 49
GC/HRMS	EPA 1668A/1668C	PCB 50
GC/HRMS	EPA 1668A/1668C	PCB 51
GC/HRMS	EPA 1668A/1668C	PCB 52
GC/HRMS	EPA 1668A/1668C	PCB 53
GC/HRMS	EPA 1668A/1668C	PCB 54
GC/HRMS	EPA 1668A/1668C	PCB 55
GC/HRMS	EPA 1668A/1668C	PCB 56
GC/HRMS	EPA 1668A/1668C	PCB 57
GC/HRMS	EPA 1668A/1668C	PCB 58
GC/HRMS	EPA 1668A/1668C	PCB 59
GC/HRMS	EPA 1668A/1668C	PCB 60
GC/HRMS	EPA 1668A/1668C	PCB 61
GC/HRMS	EPA 1668A/1668C	PCB 62
GC/HRMS	EPA 1668A/1668C	PCB 63
GC/HRMS	EPA 1668A/1668C	PCB 64
GC/HRMS	EPA 1668A/1668C	PCB 65
GC/HRMS	EPA 1668A/1668C	PCB 66
GC/HRMS	EPA 1668A/1668C	PCB 67
GC/HRMS	EPA 1668A/1668C	PCB 68
GC/HRMS	EPA 1668A/1668C	PCB 69
GC/HRMS	EPA 1668A/1668C	PCB 70

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 71
GC/HRMS	EPA 1668A/1668C	PCB 72
GC/HRMS	EPA 1668A/1668C	PCB 73
GC/HRMS	EPA 1668A/1668C	PCB 74
GC/HRMS	EPA 1668A/1668C	PCB 75
GC/HRMS	EPA 1668A/1668C	PCB 76
GC/HRMS	EPA 1668A/1668C	PCB 77
GC/HRMS	EPA 1668A/1668C	PCB 78
GC/HRMS	EPA 1668A/1668C	PCB 79
GC/HRMS	EPA 1668A/1668C	PCB 80
GC/HRMS	EPA 1668A/1668C	PCB 81
GC/HRMS	EPA 1668A/1668C	PCB 82
GC/HRMS	EPA 1668A/1668C	PCB 83
GC/HRMS	EPA 1668A/1668C	PCB 84
GC/HRMS	EPA 1668A/1668C	PCB 85
GC/HRMS	EPA 1668A/1668C	PCB 86
GC/HRMS	EPA 1668A/1668C	PCB 87
GC/HRMS	EPA 1668A/1668C	PCB 88
GC/HRMS	EPA 1668A/1668C	PCB 89
GC/HRMS	EPA 1668A/1668C	PCB 90
GC/HRMS	EPA 1668A/1668C	PCB 91
GC/HRMS	EPA 1668A/1668C	PCB 92
GC/HRMS	EPA 1668A/1668C	PCB 93
GC/HRMS	EPA 1668A/1668C	PCB 94
GC/HRMS	EPA 1668A/1668C	PCB 95
GC/HRMS	EPA 1668A/1668C	PCB 96
GC/HRMS	EPA 1668A/1668C	PCB 97
GC/HRMS	EPA 1668A/1668C	PCB 98
GC/HRMS	EPA 1668A/1668C	PCB 99
GC/HRMS	EPA 1668A/1668C	PCB 100
GC/HRMS	EPA 1668A/1668C	PCB 101
GC/HRMS	EPA 1668A/1668C	PCB 102
GC/HRMS	EPA 1668A/1668C	PCB 103
GC/HRMS	EPA 1668A/1668C	PCB 104
GC/HRMS	EPA 1668A/1668C	PCB 105
GC/HRMS	EPA 1668A/1668C	PCB 106

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 107
GC/HRMS	EPA 1668A/1668C	PCB 108
GC/HRMS	EPA 1668A/1668C	PCB 109
GC/HRMS	EPA 1668A/1668C	PCB 110
GC/HRMS	EPA 1668A/1668C	PCB 111
GC/HRMS	EPA 1668A/1668C	PCB 112
GC/HRMS	EPA 1668A/1668C	PCB 113
GC/HRMS	EPA 1668A/1668C	PCB 114
GC/HRMS	EPA 1668A/1668C	PCB 115
GC/HRMS	EPA 1668A/1668C	PCB 116
GC/HRMS	EPA 1668A/1668C	PCB 117
GC/HRMS	EPA 1668A/1668C	PCB 118
GC/HRMS	EPA 1668A/1668C	PCB 119
GC/HRMS	EPA 1668A/1668C	PCB 120
GC/HRMS	EPA 1668A/1668C	PCB 121
GC/HRMS	EPA 1668A/1668C	PCB 122
GC/HRMS	EPA 1668A/1668C	PCB 123
GC/HRMS	EPA 1668A/1668C	PCB 124
GC/HRMS	EPA 1668A/1668C	PCB 125
GC/HRMS	EPA 1668A/1668C	PCB 126
GC/HRMS	EPA 1668A/1668C	PCB 127
GC/HRMS	EPA 1668A/1668C	PCB 128
GC/HRMS	EPA 1668A/1668C	PCB 129
GC/HRMS	EPA 1668A/1668C	PCB 130
GC/HRMS	EPA 1668A/1668C	PCB 131
GC/HRMS	EPA 1668A/1668C	PCB 132
GC/HRMS	EPA 1668A/1668C	PCB 133
GC/HRMS	EPA 1668A/1668C	PCB 134
GC/HRMS	EPA 1668A/1668C	PCB 135
GC/HRMS	EPA 1668A/1668C	PCB 136
GC/HRMS	EPA 1668A/1668C	PCB 137
GC/HRMS	EPA 1668A/1668C	PCB 138
GC/HRMS	EPA 1668A/1668C	PCB 139
GC/HRMS	EPA 1668A/1668C	PCB 140
GC/HRMS	EPA 1668A/1668C	PCB 141
GC/HRMS	EPA 1668A/1668C	PCB 142

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 143
GC/HRMS	EPA 1668A/1668C	PCB 144
GC/HRMS	EPA 1668A/1668C	PCB 145
GC/HRMS	EPA 1668A/1668C	PCB 146
GC/HRMS	EPA 1668A/1668C	PCB 147
GC/HRMS	EPA 1668A/1668C	PCB 148
GC/HRMS	EPA 1668A/1668C	PCB 149
GC/HRMS	EPA 1668A/1668C	PCB 150
GC/HRMS	EPA 1668A/1668C	PCB 151
GC/HRMS	EPA 1668A/1668C	PCB 152
GC/HRMS	EPA 1668A/1668C	PCB 153
GC/HRMS	EPA 1668A/1668C	PCB 154
GC/HRMS	EPA 1668A/1668C	PCB 155
GC/HRMS	EPA 1668A/1668C	PCB 156
GC/HRMS	EPA 1668A/1668C	PCB 157
GC/HRMS	EPA 1668A/1668C	PCB 158
GC/HRMS	EPA 1668A/1668C	PCB 159
GC/HRMS	EPA 1668A/1668C	PCB 160
GC/HRMS	EPA 1668A/1668C	PCB 161
GC/HRMS	EPA 1668A/1668C	PCB 162
GC/HRMS	EPA 1668A/1668C	PCB 163
GC/HRMS	EPA 1668A/1668C	PCB 164
GC/HRMS	EPA 1668A/1668C	PCB 165
GC/HRMS	EPA 1668A/1668C	PCB 166
GC/HRMS	EPA 1668A/1668C	PCB 167
GC/HRMS	EPA 1668A/1668C	PCB 168
GC/HRMS	EPA 1668A/1668C	PCB 169
GC/HRMS	EPA 1668A/1668C	PCB 170
GC/HRMS	EPA 1668A/1668C	PCB 171
GC/HRMS	EPA 1668A/1668C	PCB 172
GC/HRMS	EPA 1668A/1668C	PCB 173
GC/HRMS	EPA 1668A/1668C	PCB 174
GC/HRMS	EPA 1668A/1668C	PCB 175
GC/HRMS	EPA 1668A/1668C	PCB 176
GC/HRMS	EPA 1668A/1668C	PCB 177
GC/HRMS	EPA 1668A/1668C	PCB 178

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 179
GC/HRMS	EPA 1668A/1668C	PCB 180
GC/HRMS	EPA 1668A/1668C	PCB 181
GC/HRMS	EPA 1668A/1668C	PCB 182
GC/HRMS	EPA 1668A/1668C	PCB 183
GC/HRMS	EPA 1668A/1668C	PCB 184
GC/HRMS	EPA 1668A/1668C	PCB 185
GC/HRMS	EPA 1668A/1668C	PCB 186
GC/HRMS	EPA 1668A/1668C	PCB 187
GC/HRMS	EPA 1668A/1668C	PCB 188
GC/HRMS	EPA 1668A/1668C	PCB 189
GC/HRMS	EPA 1668A/1668C	PCB 190
GC/HRMS	EPA 1668A/1668C	PCB 191
GC/HRMS	EPA 1668A/1668C	PCB 192
GC/HRMS	EPA 1668A/1668C	PCB 193
GC/HRMS	EPA 1668A/1668C	PCB 194
GC/HRMS	EPA 1668A/1668C	PCB 195
GC/HRMS	EPA 1668A/1668C	PCB 196
GC/HRMS	EPA 1668A/1668C	PCB 197
GC/HRMS	EPA 1668A/1668C	PCB 198
GC/HRMS	EPA 1668A/1668C	PCB 199
GC/HRMS	EPA 1668A/1668C	PCB 200
GC/HRMS	EPA 1668A/1668C	PCB 201
GC/HRMS	EPA 1668A/1668C	PCB 202
GC/HRMS	EPA 1668A/1668C	PCB 203
GC/HRMS	EPA 1668A/1668C	PCB 204
GC/HRMS	EPA 1668A/1668C	PCB 205
GC/HRMS	EPA 1668A/1668C	PCB 206
GC/HRMS	EPA 1668A/1668C	PCB 207
GC/HRMS	EPA 1668A/1668C	PCB 208
GC/HRMS	EPA 1668A/1668C	PCB 209
Preparation	**Method**	**Type**
Acid Digestion (Aqueous)	EPA 3005A/3010A	Inorganics
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	Semivolatile and Non-Volatile Organics
Solid Phase Extraction	EPA 3535A	Semivolatile and Non-Volatile Organics
Purge and Trap	EPA 5030B/5030C	Volatile Organic Compounds

Non-Potable Water		
Technology	**Method**	**Analyte**
Florisil Cleanup	EPA 3620B/3620C	Cleanup of pesticide residues and other chlorinated hydrocarbons
Sulfur Cleanup	EPA 3660A	Sulfur Cleanup
Sulfuric Acid Cleanup	EPA 3665A	Sulfuric Acid Cleanup for PCBs
Silica Gel Cleanup	EPA 3630C	Column Cleanup

Drinking Water		
Technology	**Method**	**Analyte**
LC/MS/MS	EPA 537	Perfluorobutane Sulfonic Acid (PFBS)
LC/MS/MS	EPA 537	Perfluoroheptanoic acid (PFHpA)
LC/MS/MS	EPA 537	Perfluorohexane Sulfonic Acid (PFHxS)
LC/MS/MS	EPA 537	Perfluorononanoic acid (PFNA)
LC/MS/MS	EPA 537	Perfluorooctanoic acid (PFOA)
LC/MS/MS	EPA 537	Perfluorooctane Sulfonic Acid(PFOS)
Preparation	**Method**	**Type**
Solid Phase Extraction	EPA 537	Perfluoro compounds in Drinking Water

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/6010C	Aluminum
ICP-AES	EPA 6010B/6010C	Antimony
ICP-AES	EPA 6010B/6010C	Arsenic
ICP-AES	EPA 6010B/6010C	Barium
ICP-AES	EPA 6010B/6010C	Beryllium
ICP-AES	EPA 6010B/6010C	Boron
ICP-AES	EPA 6010B/6010C	Cadmium
ICP-AES	EPA 6010B/6010C	Calcium
ICP-AES	EPA 6010B/6010C	Chromium (Total)
ICP-AES	EPA 6010B/6010C	Cobalt
ICP-AES	EPA 6010B/6010C	Copper
ICP-AES	EPA 6010B/6010C	Iron
ICP-AES	EPA 6010B/6010C	Lead
ICP-AES	EPA 6010B/6010C	Magnesium

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/6010C	Manganese
ICP-AES	EPA 6010B/6010C	Molybdenum
ICP-AES	EPA 6010B/6010C	Nickel
ICP-AES	EPA 6010B/6010C	Potassium
ICP-AES	EPA 6010B/6010C	Selenium
ICP-AES	EPA 6010B/6010C	Silver
ICP-AES	EPA 6010B/6010C	Sodium
ICP-AES	EPA 6010B/6010C	Thallium
ICP-AES	EPA 6010B/6010C	Tin
ICP-AES	EPA 6010B/6010C	Titanium
ICP-AES	EPA 6010B/6010C	Vanadium
ICP-AES	EPA 6010B/6010C	Zinc
ICP-MS	EPA 6020/6020A	Aluminum
ICP-MS	EPA 6020/6020A	Antimony
ICP-MS	EPA 6020/6020A	Arsenic
ICP-MS	EPA 6020/6020A	Barium
ICP-MS	EPA 6020/6020A	Beryllium
ICP-MS	EPA 6020/6020A	Cadmium
ICP-MS	EPA 6020/6020A	Calcium
ICP-MS	EPA 6020/6020A	Chromium (Total)
ICP-MS	EPA 6020/6020A	Cobalt
ICP-MS	EPA 6020/6020A	Copper
ICP-MS	EPA 6020/6020A	Iron
ICP-MS	EPA 6020/6020A	Lead
ICP-MS	EPA 6020/6020A	Magnesium
ICP-MS	EPA 6020/6020A	Manganese
ICP-MS	EPA 6020/6020A	Molybdenum
ICP-MS	EPA 6020/6020A	Nickel
ICP-MS	EPA 6020/6020A	Phosphorus
ICP-MS	EPA 6020/6020A	Potassium
ICP-MS	EPA 6020/6020A	Selenium
ICP-MS	EPA 6020/6020A	Silver
ICP-MS	EPA 6020/6020A	Sodium
ICP-MS	EPA 6020/6020A	Strontium
ICP-MS	EPA 6020/6020A	Thallium
ICP-MS	EPA 6020/6020A	Tin

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/6020A	Titanium
ICP-MS	EPA 6020/6020A	Uranium
ICP-MS	EPA 6020/6020A	Vanadium
ICP-MS	EPA 6020/6020A	Zinc
CVAAS	EPA 7471A/7471B	Mercury
Colorimetric	EPA 353.2	Nitrate
Colorimetric	EPA 353.2	Nitrate-nitrite
Colorimetric	EPA 353.2	Nitrite
Colorimetric/Hydrolysis	EPA 353.2 Modified /WS-WC-0050	Nitrocellulose
LC/MS/MS	EPA 6850	Perchlorate
Probe	EPA 9045C/9045D	pH
Ion Chromatography	EPA 9056A/300.0	Bromide
Ion Chromatography	EPA 9056A/300.0	Chloride
Ion Chromatography	EPA 9056A/300.0	Fluoride
Ion Chromatography	EPA 9056A/300.0	Sulfate
Ion Chromatography	EPA 9056A/300.0	Nitrate
Ion Chromatography	EPA 9056A/300.0	Nitrite
Gravimetric	ASTM D2216	%Moisture
GC/MS	EPA 8260B/8260C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C	1,1,1-Trichloroethane
GC/MS	EPA 8260B/8260C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C	1,1,2-Trichloroethane
GC/MS	EPA 8260B/8260C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 8260B/8260C	1,1-Dichloroethane
GC/MS	EPA 8260B/8260C	1,1-Dichloroethene
GC/MS	EPA 8260B/8260C	1,1-Dichloropropene
GC/MS	EPA 8260B/8260C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/8260C	1,2,3-Trichloropropane
GC/MS	EPA 8260B/8260C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/8260C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/8260C	1,2-Dibromo-3-chloropropane
GC/MS	EPA 8260B/8260C	1,2-Dibromoethane
GC/MS	EPA 8260B/8260C	1,2-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1,2-Dichloroethane
GC/MS	EPA 8260B/8260C	1,2-Dichloropropane
GC/MS	EPA 8260B/8260C	1,3,5-Trimethylbenzene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C	1,3-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1,3-Dichloropropane
GC/MS	EPA 8260B/8260C	1,4-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1-Chlorohexane
GC/MS	EPA 8260B/8260C	2,2-Dichloropropane
GC/MS	EPA 8260B/8260C	2-Butanone (MEK)
GC/MS	EPA 8260B/8260C	2-Chlorotoluene
GC/MS	EPA 8260B/8260C	2-Hexanone (MBK)
GC/MS	EPA 8260B/8260C	2-Methyl-2-propanol (tert- Butyl Alcohol, TBA)
GC/MS	EPA 8260B/8260C	4-Chlorotoluene
GC/MS	EPA 8260B/8260C	4-Isopropyltoluene
GC/MS	EPA 8260B/8260C	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA 8260B/8260C	Acetone
GC/MS	EPA 8260B/8260C	Allyl Chloride
GC/MS	EPA 8260B/8260C	Benzene
GC/MS	EPA 8260B/8260C	Bromobenzene
GC/MS	EPA 8260B/8260C	Bromochloromethane
GC/MS	EPA 8260B/8260C	Bromodichloromethane
GC/MS	EPA 8260B/8260C	Bromoform
GC/MS	EPA 8260B/8260C	Bromomethane
GC/MS	EPA 8260B/8260C	Carbon Disulfide
GC/MS	EPA 8260B/8260C	Carbon Tetrachloride
GC/MS	EPA 8260B/8260C	Chlorobenzene
GC/MS	EPA 8260B/8260C	Chloroethane
GC/MS	EPA 8260B/8260C	Chloroform
GC/MS	EPA 8260B/8260C	Chloromethane
GC/MS	EPA 8260B/8260C	cis-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C	Cyclohexane
GC/MS	EPA 8260B/8260C	Dibromochloromethane
GC/MS	EPA 8260B/8260C	Dibromomethane
GC/MS	EPA 8260B/8260C	Dichlorodifluoromethane
GC/MS	EPA 8260B/8260C	Diisopropyl Ether (DIPE)
GC/MS	EPA 8260B/8260C	Ethylbenzene
GC/MS	EPA 8260B/8260C	Ethylmethacrylate
GC/MS	EPA 8260B/8260C	Ethyl tert-butyl Ether (ETBE)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C	Hexachlorobutadiene
GC/MS	EPA 8260B/8260C	Hexane
GC/MS	EPA 8260B/8260C	Iodomethane
GC/MS	EPA 8260B/8260C	Isobutanol (2-Methyl-1-propanol)
GC/MS	EPA 8260B/8260C	Isopropylbenzene
GC/MS	EPA 8260B/8260C	m & p Xylene
GC/MS	EPA 8260B/8260C	Methyl tert-butyl Ether (MTBE)
GC/MS	EPA 8260B/8260C	Methylene Chloride
GC/MS	EPA 8260B/8260C	Naphthalene
GC/MS	EPA 8260B/8260C	n-Butylbenzene
GC/MS	EPA 8260B/8260C	n-Propylbenzene
GC/MS	EPA 8260B/8260C	o-Xylene
GC/MS	EPA 8260B/8260C	sec-Butylbenzene
GC/MS	EPA 8260B/8260C	Styrene
GC/MS	EPA 8260B/8260C	t-Amyl methyl Ether (TAME)
GC/MS	EPA 8260B/8260C	t-1,4-Dichloro-2-Butene
GC/MS	EPA 8260B/8260C	tert-Butylbenzene
GC/MS	EPA 8260B/8260C	Tetrachloroethene
GC/MS	EPA 8260B/8260C	Toluene
GC/MS	EPA 8260B/8260C	trans-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C	trans-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C	Trichloroethene
GC/MS	EPA 8260B/8260C	Trichlorofluoromethane
GC/MS	EPA 8260B/8260C	Vinyl Acetate
GC/MS	EPA 8260B/8260C	Vinyl Chloride
GC/MS	EPA 8260B/8260C	Xylenes, Total
GC/MS	EPA 8260B/AK101MS	Gasoline Range Organics (GRO)
GC/MS	EPA 8270C/8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/8270D	1,2-Dichlorobenzene
GC/MS	EPA 8270C/8270D	1,2-Diphenylhydrazine (as Azobenzene)
GC/MS	EPA 8270C/8270D	1,3-Dichlorobenzene
GC/MS	EPA 8270C/8270D	1,3-Dinitrobenzene
GC/MS	EPA 8270C/8270D	1,4-Dichlorobenzene
GC/MS	EPA 8270C/8270D	1-Methylnaphthalene
GC/MS	EPA 8270C/8270D	2,3,4,6-Tetrachlorophenol

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270C/8270D	2,4-Dichlorophenol
GC/MS	EPA 8270C/8270D	2,4-Dimethylphenol
GC/MS	EPA 8270C/8270D	2,4-Dinitrophenol
GC/MS	EPA 8270C/8270D	2,4-Dinitrotoluene
GC/MS	EPA 8270C/8270D	2,6-Dichlorophenol
GC/MS	EPA 8270C/8270D	2,6-Dinitrotoluene
GC/MS	EPA 8270C/8270D	2-Chloronaphthalene
GC/MS	EPA 8270C/8270D	2-Chlorophenol
GC/MS	EPA 8270C/8270D	2-Methylnaphthalene
GC/MS	EPA 8270C/8270D	2-Methylphenol
GC/MS	EPA 8270C/8270D	2-Nitroaniline
GC/MS	EPA 8270C/8270D	2-Nitrophenol
GC/MS	EPA 8270C/8270D	3&4-Methylphenol
GC/MS	EPA 8270C/8270D	3,3'-Dichlorobenzidine
GC/MS	EPA 8270C/8270D	3-Nitroaniline
GC/MS	EPA 8270C/8270D	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270C/8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/8270D	4-Chloroaniline
GC/MS	EPA 8270C/8270D	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/8270D	4-Nitroaniline
GC/MS	EPA 8270C/8270D	4-Nitrophenol
GC/MS	EPA 8270C/8270D	Acenaphthene
GC/MS	EPA 8270C/8270D	Acenaphthylene
GC/MS	EPA 8270C/8270D	Aniline
GC/MS	EPA 8270C/8270D	Anthracene
GC/MS	EPA 8270C/8270D	Benzo(a)anthracene
GC/MS	EPA 8270C/8270D	Benzo(a)pyrene
GC/MS	EPA 8270C/8270D	Benzo(b)fluoranthene
GC/MS	EPA 8270C/8270D	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/8270D	Benzo(k)fluoranthene
GC/MS	EPA 8270C/8270D	Benzoic Acid
GC/MS	EPA 8270C/8270D	Benzyl Alcohol
GC/MS	EPA 8270C/8270D	Benzyl butyl Phthalate

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D	Biphenyl
GC/MS	EPA 8270C/8270D	Bis(2-chloroethoxy) Methane
GC/MS	EPA 8270C/8270D	Bis(2-chloroethyl) Ether
GC/MS	EPA 8270C/8270D	Bis(2-chloroisopropyl) Ether
GC/MS	EPA 8270C/8270D	Carbazole
GC/MS	EPA 8270C/8270D	Chrysene
GC/MS	EPA 8270C/8270D	Bis (2-ethylhexyl) Phthalate
GC/MS	EPA 8270C/8270D	Dibenz(a,h)anthracene
GC/MS	EPA 8270C/8270D	Dibenzofuran
GC/MS	EPA 8270C/8270D	Diethyl Phthalate
GC/MS	EPA 8270C/8270D	Dimethyl Phthalate
GC/MS	EPA 8270C/8270D	Di-n-butyl Phthalate
GC/MS	EPA 8270C/8270D	Di-n-octyl Phthalate
GC/MS	EPA 8270C/8270D	Fluoranthene
GC/MS	EPA 8270C/8270D	Fluorene
GC/MS	EPA 8270C/8270D	Hexachlorobenzene
GC/MS	EPA 8270C/8270D	Hexachlorobutadiene
GC/MS	EPA 8270C/8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270C/8270D	Hexachloroethane
GC/MS	EPA 8270C/8270D	Indeno(1,2,3-c,d) Pyrene
GC/MS	EPA 8270C/8270D	Isophorone
GC/MS	EPA 8270C/8270D	Naphthalene
GC/MS	EPA 8270C/8270D	Nitrobenzene
GC/MS	EPA 8270C/8270D	n-Nitrosodimethylamine
GC/MS	EPA 8270C/8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270C/8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270C/8270D	Pentachlorophenol
GC/MS	EPA 8270C/8270D	Phenanthrene
GC/MS	EPA 8270C/8270D	Phenol
GC/MS	EPA 8270C/8270D	Pyrene
GC/MS	EPA 8270C/8270D	Pyridine
GC/MS SIM	EPA 8260C-SIM	1,1,2-Trichloroethane
GC/MS SIM	EPA 8260C-SIM	1,1,2,2-Tetrachloroethane
GC/MS SIM	EPA 8260C-SIM	1,2,3-Trichloropropane
GC/MS SIM	EPA 8260C-SIM	1,2-Dibromoethane
GC/MS SIM	EPA 8260C-SIM	1,2-Dichloroethane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8260C-SIM	1,3-Butadiene
GC/MS SIM	EPA 8260C-SIM	1,4-Dichlorobenzene
GC/MS SIM	EPA 8260C-SIM	Benzene
GC/MS SIM	EPA 8260C-SIM	Bromodichloromethane
GC/MS SIM	EPA 8260C-SIM	Bromoform
GC/MS SIM	EPA 8260C-SIM	Bromomethane
GC/MS SIM	EPA 8260C-SIM	Chloroform
GC/MS SIM	EPA 8260C-SIM	Dibromochloromethane
GC/MS SIM	EPA 8260C-SIM	Dibromomethane
GC/MS SIM	EPA 8260C-SIM	Hexachlorobutadiene
GC/MS SIM	EPA 8260C-SIM	Naphthalene
GC/MS SIM	EPA 8260C-SIM	Tetrachloroethene
GC/MS SIM	EPA 8260C-SIM	Trichloroethene
GC/MS SIM	EPA 8260C-SIM	Vinyl Chloride
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	1-Methylnaphthalene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	2-Methylnaphthalene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Acenaphthene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Acenaphthylene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Anthracene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(a)anthracene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(a)pyrene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(b)fluoranthene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(g,h,i)perylene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Benzo(k)fluoranthene
GC/MS SIM	EPA 8270D-SIM	Bis(2-chloroethyl) Ether
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Chrysene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Dibenz(a,h)anthracene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Fluoranthene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Fluorene
GC/MS SIM	EPA 8270D-SIM	Hexachlorobenzene
GC/MS SIM	EPA 8270D-SIM	Hexachlorocyclopentadiene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Indeno(1,2,3-c,d) Pyrene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Naphthalene
GC/MS SIM	EPA 8270D-SIM	n-Nitrosodi-n-propylamine
GC/MS SIM	EPA 8270D-SIM	Pentachlorophenol
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Phenanthrene
GC/MS SIM	EPA 8270C-SIM EPA 8270D-SIM	Pyrene
GC/MS SIM	EPA 521 Modified / WS-MS-0012	N-Nitrosodimethyl amine (NDMA)
GC-FID	EPA 8015B/8015C/8015D AK102	Diesel Range Organics (DRO)
GC-FID	AK103	Residual Range Organics
GC-FID	EPA 8015B/8015C/8015D	Motor Oil Range Organics (MRO)
GC-ECD	EPA 8081A/8081B	Aldrin
GC-ECD	EPA 8081A/8081B	a-BHC
GC-ECD	EPA 8081A/8081B	b-BHC
GC-ECD	EPA 8081A/8081B	d-BHC
GC-ECD	EPA 8081A/8081B	g-BHC (Lindane)
GC-ECD	EPA 8081A/8081B	a-Chlordane
GC-ECD	EPA 8081A/8081B	g-Chlordane
GC-ECD	EPA 8081A/8081B	4,4'-DDD
GC-ECD	EPA 8081A/8081B	4,4'-DDE
GC-ECD	EPA 8081A/8081B	4,4'-DDT
GC-ECD	EPA 8081A/8081B	Dieldrin
GC-ECD	EPA 8081A/8081B	Endosulfan I
GC-ECD	EPA 8081A/8081B	Endosulfan II
GC-ECD	EPA 8081A/8081B	Endosulfan sulfate
GC-ECD	EPA 8081A/8081B	Endrin
GC-ECD	EPA 8081A/8081B	Endrin Aldehyde

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-ECD	EPA 8081A/8081B	Endrin Ketone
GC-ECD	EPA 8081A/8081B	Heptachlor
GC-ECD	EPA 8081A/8081B	Heptachlor Epoxide
GC-ECD	EPA 8081A/8081B	Methoxychlor
GC-ECD	EPA 8081A/8081B	Toxaphene
GC-ECD	EPA 8081A/8081B	Chlordane (technical)
GC-ECD	EPA 8082/8082A	PCB-1016
GC-ECD	EPA 8082/8082A	PCB-1221
GC-ECD	EPA 8082/8082A	PCB-1232
GC-ECD	EPA 8082/8082A	PCB-1242
GC-ECD	EPA 8082/8082A	PCB-1248
GC-ECD	EPA 8082/8082A	PCB-1254
GC-ECD	EPA 8082/8082A	PCB-1260
GC-ECD	EPA 8082/8082A	PCB-1262
GC-ECD	EPA 8082/8082A	PCB-1268
GC/MS	EPA 8280A/8280B	2,3,7,8-TeCDD
GC/MS	EPA 8280A/8280B	1,2,3,7,8-PeCDD
GC/MS	EPA 8280A/8280B	1,2,3,4,7,8-HxCDD
GC/MS	EPA 8280A/8280B	1,2,3,6,7,8-HxCDD
GC/MS	EPA 8280A/8280B	1,2,3,7,8,9-HxCDD
GC/MS	EPA 8280A/8280B	1,2,3,4,6,7,8-HpCDD
GC/MS	EPA 8280A/8280B	OCDD
GC/MS	EPA 8280A/8280B	2,3,7,8-TeCDF
GC/MS	EPA 8280A/8280B	1,2,3,7,8-PeCDF
GC/MS	EPA 8280A/8280B	2,3,4,7,8-PeCDF
GC/MS	EPA 8280A/8280B	1,2,3,4,7,8-HxCDF
GC/MS	EPA 8280A/8280B	1,2,3,6,7,8-HxCDF
GC/MS	EPA 8280A/8280B	1,2,3,7,8,9-HxCDF
GC/MS	EPA 8280A/8280B	2,3,4,6,7,8-HxCDF
GC/MS	EPA 8280A/8280B	1,2,3,4,6,7,8-HpCDF
GC/MS	EPA 8280A/8280B	1,2,3,4,7,8,9-HpCDF
GC/MS	EPA 8280A/8280B	OCDF
GC/MS	EPA 8280A/8280B	Total TCDD
GC/MS	EPA 8280A/8280B	Total PeCDD
GC/MS	EPA 8280A/8280B	Total HxCDD
GC/MS	EPA 8280A/8280B	Total HeptaCDD

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8280A/8280B	Total TCDF
GC/MS	EPA 8280A/8280B	Total PeCDF
GC/MS	EPA 8280A/8280B	Total HxCDF
GC/MS	EPA 8280A/8280B	Total HpCDF
GC/HRMS	EPA 8290/ 8290A/1613B	2,3,7,8-TeCDD
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,7,8-PeCDD
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,4,7,8-HxCDD
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,6,7,8-HxCDD
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,7,8,9-HxCDD
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,4,6,7,8-HpCDD
GC/HRMS	EPA 8290/ 8290A/1613B	OCDD
GC/HRMS	EPA 8290/ 8290A/1613B	2,3,7,8-TeCDF
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,7,8-PeCDF
GC/HRMS	EPA 8290/ 8290A/1613B	2,3,4,7,8-PeCDF
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,4,7,8-HxCDF
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,6,7,8-HxCDF
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,7,8,9-HxCDF
GC/HRMS	EPA 8290/ 8290A/1613B	2,3,4,6,7,8-HxCDF
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,4,6,7,8-HpCDF
GC/HRMS	EPA 8290/ 8290A/1613B	1,2,3,4,7,8,9-HpCDF
GC/HRMS	EPA 8290/ 8290A/1613B	OCDF
GC/HRMS	EPA 8290/ 8290A/1613B	Total TCDD
GC/HRMS	EPA 8290/ 8290A/1613B	Total PeCDD
GC/HRMS	EPA 8290/ 8290A/1613B	Total HxCDD
GC/HRMS	EPA 8290/ 8290A/1613B	Total HpCDD
GC/HRMS	EPA 8290/ 8290A/1613B	Total TCDF
GC/HRMS	EPA 8290/ 8290A/1613B	Total PeCDF
GC/HRMS	EPA 8290/ 8290A/1613B	Total HxCDF
GC/HRMS	EPA 8290/ 8290A/1613B	Total HpCDF
HPLC/UV	EPA 8330A/8330B	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330A/8330B	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330A/8330B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/8330B	1,3-Dinitrobenzene
HPLC/UV	EPA 8330A/8330B	2,4-Dinitrotoluene
HPLC/UV	EPA 8330A/8330B	2,6-Dinitrotoluene
HPLC/UV	EPA 8330A/8330B	Glycerol trinitrate (Nitroglycerin)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
HPLC/UV	EPA 8330A/8330B	Hexahydro-1,3,5-trinitro- 1,3,5-triazine (Hexogen)
HPLC/UV	EPA 8330A/8330B	Methyl-2,4,6- trinitrophenylnitramine
HPLC/UV	EPA 8330A/8330B	Nitrobenzene
HPLC/UV	EPA 8330A/8330B	2-Nitrotoluene (o-Nitrotoluene)
HPLC/UV	EPA 8330A/8330B	3-Nitrotoluene (m-Nitrotoluene)
HPLC/UV	EPA 8330A/8330B	4-Nitrotoluene (p-Nitrotoluene)
HPLC/UV	EPA 8330A/8330B	Octahydro-1,3,5,7- tetranitro1,3,5,7-tetracine (Octogen)
HPLC/UV	EPA 8330A/8330B	Picric acid
HPLC/UV	EPA 8330A/8330B	Pentaerythritol Tetranitrate
HPLC/UV	EPA 8330A/8330B	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330A/8330B	2,4,6-Trinitrotoluene
HPLC/UV	EPA 8330A/8330B	Hexahydro-1,3-dinitroso-5- nitro-1,3,5,triazine (DNX)
HPLC/UV	EPA 8330A/8330B	Hexahydro-1,3,5-trinitroso- 1,3,5-triazine (TNX)
HPLC/UV	EPA 8330A/8330B	1-Nitroso-3,5-dinitro-1,3,5- triazacyclohexane (MNX)
HPLC/UV	EPA 8330A Modified / WS-LC-0010	Nitroguanidine
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	6:2 Fluorotelomer sulfonate (6:2 FTS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	8:2 Fluorotelomer sulfonate (8:2 FTS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	N-Ethyl perfluorooctanesulfon amidacetic acid (EtFOSAA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	N-Methyl perfluorooctanesulfon amidoacetic acide (MeFOSAA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorooctanoic acid (PFOA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorooctane Sulfonic Acid (PFOS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant /	Perfluorobutyric acid (PFBA)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
	WS-LC-0025	
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoropentanoic acid (PFPA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorohexanoic acid (PFHxA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoroheptanoic acid (PFHpA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorononanoic acid (PFNA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorodecanoic acid (PFDA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoroundecanoic acid (PFUDA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorododecanoic acid (PFDoDA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorotridecanoic acid (PFTriA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorotetradecanoic acid (PDTeA)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorobutane Sulfonic Acid (PFBS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorohexane Sulfonic Acid (PFHxS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluoroheptane Sulfonic Acid (PFHpS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant / WS-LC-0025	Perfluorodecane Sulfonic Acid (PFDS)
LC/MS/MS	EPA 537 Modified-Table B15 Compliant /	Perfluoroocatane Sulfonamide (FOSA)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
	WS-LC-0025	
GC/HRMS	EPA 1668A/1668C	PCB 1
GC/HRMS	EPA 1668A/1668C	PCB 2
GC/HRMS	EPA 1668A/1668C	PCB 3
GC/HRMS	EPA 1668A/1668C	PCB 4
GC/HRMS	EPA 1668A/1668C	PCB 5
GC/HRMS	EPA 1668A/1668C	PCB 6
GC/HRMS	EPA 1668A/1668C	PCB 7
GC/HRMS	EPA 1668A/1668C	PCB 8
GC/HRMS	EPA 1668A/1668C	PCB 9
GC/HRMS	EPA 1668A/1668C	PCB 10
GC/HRMS	EPA 1668A/1668C	PCB 11
GC/HRMS	EPA 1668A/1668C	PCB 12
GC/HRMS	EPA 1668A/1668C	PCB 13
GC/HRMS	EPA 1668A/1668C	PCB 14
GC/HRMS	EPA 1668A/1668C	PCB 15
GC/HRMS	EPA 1668A/1668C	PCB 16
GC/HRMS	EPA 1668A/1668C	PCB 17
GC/HRMS	EPA 1668A/1668C	PCB 18
GC/HRMS	EPA 1668A/1668C	PCB 19
GC/HRMS	EPA 1668A/1668C	PCB 20
GC/HRMS	EPA 1668A/1668C	PCB 21
GC/HRMS	EPA 1668A/1668C	PCB 22
GC/HRMS	EPA 1668A/1668C	PCB 23
GC/HRMS	EPA 1668A/1668C	PCB 24
GC/HRMS	EPA 1668A/1668C	PCB 25
GC/HRMS	EPA 1668A/1668C	PCB 26
GC/HRMS	EPA 1668A/1668C	PCB 27
GC/HRMS	EPA 1668A/1668C	PCB 28
GC/HRMS	EPA 1668A/1668C	PCB 29
GC/HRMS	EPA 1668A/1668C	PCB 30
GC/HRMS	EPA 1668A/1668C	PCB 32
GC/HRMS	EPA 1668A/1668C	PCB 31
GC/HRMS	EPA 1668A/1668C	PCB 33
GC/HRMS	EPA 1668A/1668C	PCB 34
GC/HRMS	EPA 1668A/1668C	PCB 35

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 36
GC/HRMS	EPA 1668A/1668C	PCB 37
GC/HRMS	EPA 1668A/1668C	PCB 38
GC/HRMS	EPA 1668A/1668C	PCB 39
GC/HRMS	EPA 1668A/1668C	PCB 40
GC/HRMS	EPA 1668A/1668C	PCB 41
GC/HRMS	EPA 1668A/1668C	PCB 42
GC/HRMS	EPA 1668A/1668C	PCB 43
GC/HRMS	EPA 1668A/1668C	PCB 44
GC/HRMS	EPA 1668A/1668C	PCB 45
GC/HRMS	EPA 1668A/1668C	PCB 46
GC/HRMS	EPA 1668A/1668C	PCB 47
GC/HRMS	EPA 1668A/1668C	PCB 48
GC/HRMS	EPA 1668A/1668C	PCB 49
GC/HRMS	EPA 1668A/1668C	PCB 50
GC/HRMS	EPA 1668A/1668C	PCB 51
GC/HRMS	EPA 1668A/1668C	PCB 52
GC/HRMS	EPA 1668A/1668C	PCB 53
GC/HRMS	EPA 1668A/1668C	PCB 54
GC/HRMS	EPA 1668A/1668C	PCB 55
GC/HRMS	EPA 1668A/1668C	PCB 56
GC/HRMS	EPA 1668A/1668C	PCB 57
GC/HRMS	EPA 1668A/1668C	PCB 58
GC/HRMS	EPA 1668A/1668C	PCB 59
GC/HRMS	EPA 1668A/1668C	PCB 60
GC/HRMS	EPA 1668A/1668C	PCB 61
GC/HRMS	EPA 1668A/1668C	PCB 62
GC/HRMS	EPA 1668A/1668C	PCB 63
GC/HRMS	EPA 1668A/1668C	PCB 64
GC/HRMS	EPA 1668A/1668C	PCB 65
GC/HRMS	EPA 1668A/1668C	PCB 66
GC/HRMS	EPA 1668A/1668C	PCB 67
GC/HRMS	EPA 1668A/1668C	PCB 68
GC/HRMS	EPA 1668A/1668C	PCB 69
GC/HRMS	EPA 1668A/1668C	PCB 70
GC/HRMS	EPA 1668A/1668C	PCB 71

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 72
GC/HRMS	EPA 1668A/1668C	PCB 73
GC/HRMS	EPA 1668A/1668C	PCB 74
GC/HRMS	EPA 1668A/1668C	PCB 75
GC/HRMS	EPA 1668A/1668C	PCB 76
GC/HRMS	EPA 1668A/1668C	PCB 77
GC/HRMS	EPA 1668A/1668C	PCB 78
GC/HRMS	EPA 1668A/1668C	PCB 79
GC/HRMS	EPA 1668A/1668C	PCB 80
GC/HRMS	EPA 1668A/1668C	PCB 81
GC/HRMS	EPA 1668A/1668C	PCB 82
GC/HRMS	EPA 1668A/1668C	PCB 83
GC/HRMS	EPA 1668A/1668C	PCB 84
GC/HRMS	EPA 1668A/1668C	PCB 85
GC/HRMS	EPA 1668A/1668C	PCB 86
GC/HRMS	EPA 1668A/1668C	PCB 87
GC/HRMS	EPA 1668A/1668C	PCB 88
GC/HRMS	EPA 1668A/1668C	PCB 89
GC/HRMS	EPA 1668A/1668C	PCB 90
GC/HRMS	EPA 1668A/1668C	PCB 91
GC/HRMS	EPA 1668A/1668C	PCB 92
GC/HRMS	EPA 1668A/1668C	PCB 93
GC/HRMS	EPA 1668A/1668C	PCB 94
GC/HRMS	EPA 1668A/1668C	PCB 95
GC/HRMS	EPA 1668A/1668C	PCB 96
GC/HRMS	EPA 1668A/1668C	PCB 97
GC/HRMS	EPA 1668A/1668C	PCB 98
GC/HRMS	EPA 1668A/1668C	PCB 99
GC/HRMS	EPA 1668A/1668C	PCB 100
GC/HRMS	EPA 1668A/1668C	PCB 101
GC/HRMS	EPA 1668A/1668C	PCB 102
GC/HRMS	EPA 1668A/1668C	PCB 103
GC/HRMS	EPA 1668A/1668C	PCB 104
GC/HRMS	EPA 1668A/1668C	PCB 105
GC/HRMS	EPA 1668A/1668C	PCB 106
GC/HRMS	EPA 1668A/1668C	PCB 107

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 108
GC/HRMS	EPA 1668A/1668C	PCB 109
GC/HRMS	EPA 1668A/1668C	PCB 110
GC/HRMS	EPA 1668A/1668C	PCB 111
GC/HRMS	EPA 1668A/1668C	PCB 112
GC/HRMS	EPA 1668A/1668C	PCB 113
GC/HRMS	EPA 1668A/1668C	PCB 114
GC/HRMS	EPA 1668A/1668C	PCB 115
GC/HRMS	EPA 1668A/1668C	PCB 116
GC/HRMS	EPA 1668A/1668C	PCB 117
GC/HRMS	EPA 1668A/1668C	PCB 118
GC/HRMS	EPA 1668A/1668C	PCB 119
GC/HRMS	EPA 1668A/1668C	PCB 120
GC/HRMS	EPA 1668A/1668C	PCB 121
GC/HRMS	EPA 1668A/1668C	PCB 122
GC/HRMS	EPA 1668A/1668C	PCB 123
GC/HRMS	EPA 1668A/1668C	PCB 124
GC/HRMS	EPA 1668A/1668C	PCB 125
GC/HRMS	EPA 1668A/1668C	PCB 126
GC/HRMS	EPA 1668A/1668C	PCB 127
GC/HRMS	EPA 1668A/1668C	PCB 128
GC/HRMS	EPA 1668A/1668C	PCB 129
GC/HRMS	EPA 1668A/1668C	PCB 130
GC/HRMS	EPA 1668A/1668C	PCB 131
GC/HRMS	EPA 1668A/1668C	PCB 132
GC/HRMS	EPA 1668A/1668C	PCB 133
GC/HRMS	EPA 1668A/1668C	PCB 134
GC/HRMS	EPA 1668A/1668C	PCB 135
GC/HRMS	EPA 1668A/1668C	PCB 136
GC/HRMS	EPA 1668A/1668C	PCB 137
GC/HRMS	EPA 1668A/1668C	PCB 138
GC/HRMS	EPA 1668A/1668C	PCB 139
GC/HRMS	EPA 1668A/1668C	PCB 140
GC/HRMS	EPA 1668A/1668C	PCB 141
GC/HRMS	EPA 1668A/1668C	PCB 142
GC/HRMS	EPA 1668A/1668C	PCB 143

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 144
GC/HRMS	EPA 1668A/1668C	PCB 145
GC/HRMS	EPA 1668A/1668C	PCB 146
GC/HRMS	EPA 1668A/1668C	PCB 147
GC/HRMS	EPA 1668A/1668C	PCB 148
GC/HRMS	EPA 1668A/1668C	PCB 149
GC/HRMS	EPA 1668A/1668C	PCB 150
GC/HRMS	EPA 1668A/1668C	PCB 151
GC/HRMS	EPA 1668A/1668C	PCB 152
GC/HRMS	EPA 1668A/1668C	PCB 153
GC/HRMS	EPA 1668A/1668C	PCB 154
GC/HRMS	EPA 1668A/1668C	PCB 155
GC/HRMS	EPA 1668A/1668C	PCB 156
GC/HRMS	EPA 1668A/1668C	PCB 157
GC/HRMS	EPA 1668A/1668C	PCB 158
GC/HRMS	EPA 1668A/1668C	PCB 159
GC/HRMS	EPA 1668A/1668C	PCB 160
GC/HRMS	EPA 1668A/1668C	PCB 161
GC/HRMS	EPA 1668A/1668C	PCB 162
GC/HRMS	EPA 1668A/1668C	PCB 163
GC/HRMS	EPA 1668A/1668C	PCB 164
GC/HRMS	EPA 1668A/1668C	PCB 165
GC/HRMS	EPA 1668A/1668C	PCB 166
GC/HRMS	EPA 1668A/1668C	PCB 167
GC/HRMS	EPA 1668A/1668C	PCB 168
GC/HRMS	EPA 1668A/1668C	PCB 169
GC/HRMS	EPA 1668A/1668C	PCB 170
GC/HRMS	EPA 1668A/1668C	PCB 171
GC/HRMS	EPA 1668A/1668C	PCB 172
GC/HRMS	EPA 1668A/1668C	PCB 173
GC/HRMS	EPA 1668A/1668C	PCB 174
GC/HRMS	EPA 1668A/1668C	PCB 175
GC/HRMS	EPA 1668A/1668C	PCB 176
GC/HRMS	EPA 1668A/1668C	PCB 177
GC/HRMS	EPA 1668A/1668C	PCB 178
GC/HRMS	EPA 1668A/1668C	PCB 179

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/HRMS	EPA 1668A/1668C	PCB 180
GC/HRMS	EPA 1668A/1668C	PCB 181
GC/HRMS	EPA 1668A/1668C	PCB 182
GC/HRMS	EPA 1668A/1668C	PCB 183
GC/HRMS	EPA 1668A/1668C	PCB 184
GC/HRMS	EPA 1668A/1668C	PCB 185
GC/HRMS	EPA 1668A/1668C	PCB 186
GC/HRMS	EPA 1668A/1668C	PCB 187
GC/HRMS	EPA 1668A/1668C	PCB 188
GC/HRMS	EPA 1668A/1668C	PCB 189
GC/HRMS	EPA 1668A/1668C	PCB 190
GC/HRMS	EPA 1668A/1668C	PCB 191
GC/HRMS	EPA 1668A/1668C	PCB 192
GC/HRMS	EPA 1668A/1668C	PCB 193
GC/HRMS	EPA 1668A/1668C	PCB 194
GC/HRMS	EPA 1668A/1668C	PCB 195
GC/HRMS	EPA 1668A/1668C	PCB 196
GC/HRMS	EPA 1668A/1668C	PCB 197
GC/HRMS	EPA 1668A/1668C	PCB 198
GC/HRMS	EPA 1668A/1668C	PCB 199
GC/HRMS	EPA 1668A/1668C	PCB 200
GC/HRMS	EPA 1668A/1668C	PCB 201
GC/HRMS	EPA 1668A/1668C	PCB 202
GC/HRMS	EPA 1668A/1668C	PCB 203
GC/HRMS	EPA 1668A/1668C	PCB 204
GC/HRMS	EPA 1668A/1668C	PCB 205
GC/HRMS	EPA 1668A/1668C	PCB 206
GC/HRMS	EPA 1668A/1668C	PCB 207
GC/HRMS	EPA 1668A/1668C	PCB 208
GC/HRMS	EPA 1668A/1668C	PCB 209
Preparation	**Method**	**Type**
Acid Digestion (Aqueous)	EPA 3005A/3010A	Inorganics
Acid Digestion (Solid)	EPA 3050B	Inorganics
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	Semivolatile and Non-Volatile Organics
Ultrasonic Extraction	EPA 3550B/3550C	Semivolatile and Non-Volatile Organics
Solvent Dilution	EPA 3580A	Semivolatile and Non-Volatile Organics

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
Purge and Trap	EPA 5030B	Volatile Organic Compounds
Purge and Trap	EPA 5035/5035A	Volatile Organic Compounds
Microwave Extraction	EPA 3546	Semivolatile and Non-Volatile Organics
Florisil Cleanup	EPA 3620B/3620C	Cleanup of pesticide residues and other chlorinated hydrocarbons
Sulfur Cleanup	EPA 3660A	Sulfur Cleanup
Sulfuric Acid Cleanup	EPA 3665A	Sulfuric Acid Cleanup for PCBs
Silica Gel Cleanup	EPA 3630C	Column Cleanup
TCLP Extraction	EPA 1311	Toxicity Characteristic Leaching Procedure

Air and Emissions		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/6020A	Aluminum
ICP-MS	EPA 6020/6020A	Antimony
ICP-MS	EPA 6020/6020A	Arsenic
ICP-MS	EPA 6020/6020A	Barium
ICP-MS	EPA 6020/6020A	Beryllium
ICP-MS	EPA 6020/6020A	Cadmium
ICP-MS	EPA 6020/6020A	Calcium
ICP-MS	EPA 6020/6020A	Chromium (Total)
ICP-MS	EPA 6020/6020A	Cobalt
ICP-MS	EPA 6020/6020A	Copper
ICP-MS	EPA 6020/6020A	Iron
ICP-MS	EPA 6020/6020A	Lead
ICP-MS	EPA 6020/6020A	Magnesium
ICP-MS	EPA 6020/6020A	Manganese
ICP-MS	EPA 6020/6020A	Molybdenum
ICP-MS	EPA 6020/6020A	Nickel
ICP-MS	EPA 6020/6020A	Potassium
ICP-MS	EPA 6020/6020A	Selenium
ICP-MS	EPA 6020/6020A	Silver
ICP-MS	EPA 6020/6020A	Sodium
ICP-MS	EPA 6020/6020A	Thallium
ICP-MS	EPA 6020/6020A	Vanadium
ICP-MS	EPA 6020/6020A	Zinc

Air and Emissions		
Technology	**Method**	**Analyte**
Gravimetric	40CFR Part 50 App B	TSP (Total Suspended Particulate)
Gravimetric	40CFR Part 50 App J	PM10
GC/MS	EPA TO-14A/TO-15	1,1,1-Trichloroethane
GC/MS	EPA TO-14A/TO-15	1,1,2,2-Tetrachloroethane
GC/MS	EPA TO-14A/TO-15	1,1,2-Trichloroethane
GC/MS	EPA TO-14A/TO-15	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA TO-14A/TO-15	1,1-Dichloroethane
GC/MS	EPA TO-14A/TO-15	1,1-Dichloroethene
GC/MS	EPA TO-14A/TO-15	1,2,3-Trichlorobenzene
GC/MS	EPA TO-14A/TO-15	1,2,3-Trichloropropane
GC/MS	EPA TO-14A/TO-15	1,2,4-Trichlorobenzene
GC/MS	EPA TO-14A/TO-15	1,2,4-Trimethylbenzene
GC/MS	EPA TO-14A/TO-15	1,2-Dibromoethane
GC/MS	EPA TO-14A/TO-15	1,2-Dichlorobenzene
GC/MS	EPA TO-14A/TO-15	1,2-Dichloroethane
GC/MS	EPA TO-14A/TO-15	1,2-Dichloropropane
GC/MS	EPA TO-14A/TO-15	1,3,5-Trimethylbenzene
GC/MS	EPA TO-14A/TO-15	1,3-Dichlorobenzene
GC/MS	EPA TO-14A/TO-15	1,4-Dichlorobenzene
GC/MS	EPA TO-14A/TO-15	1,4-Dioxane
GC/MS	EPA TO-14A/TO-15	2-Butanone (MEK)
GC/MS	EPA TO-14A/TO-15	2-Chlorotoluene
GC/MS	EPA TO-14A/TO-15	2-Hexanone (MBK)
GC/MS	EPA TO-14A/TO-15	2-Methyl-2-propanol (tert- Butyl Alcohol, TBA)
GC/MS	EPA TO-14A/TO-15	4-Ethyltoluene
GC/MS	EPA TO-14A/TO-15	4-Isopropyltoluene
GC/MS	EPA TO-14A/TO-15	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA TO-14A/TO-15	Acetone
GC/MS	EPA TO-14A/TO-15	Acrolein
GC/MS	EPA TO-14A/TO-15	Allyl Chloride
GC/MS	EPA TO-14A/TO-15	Alpha Methyl Styrene
GC/MS	EPA TO-14A/TO-15	Benzene
GC/MS	EPA TO-14A/TO-15	Benzyl Chloride
GC/MS	EPA TO-14A/TO-15	Bromodichloromethane
GC/MS	EPA TO-14A/TO-15	Bromoform
GC/MS	EPA TO-14A/TO-15	Bromomethane

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-14A/TO-15	Butadiene (1,3-Butadiene)
GC/MS	EPA TO-14A/TO-15	Butane
GC/MS	EPA TO-14A/TO-15	Carbon Disulfide
GC/MS	EPA TO-14A/TO-15	Carbon Tetrachloride
GC/MS	EPA TO-14A/TO-15	Chlorobenzene
GC/MS	EPA TO-14A/TO-15	Chlorodifluoromethane
GC/MS	EPA TO-14A/TO-15	Chloroethane
GC/MS	EPA TO-14A/TO-15	Chloroform
GC/MS	EPA TO-14A/TO-15	Chloromethane
GC/MS	EPA TO-14A/TO-15	cis-1,2-Dichloroethene
GC/MS	EPA TO-14A/TO-15	cis-1,3-Dichloropropene
GC/MS	EPA TO-14A/TO-15	Cyclohexane
GC/MS	EPA TO-14A/TO-15	Dibromochloromethane
GC/MS	EPA TO-14A/TO-15	Dibromomethane
GC/MS	EPA TO-14A/TO-15	Dichlorodifluoromethane
GC/MS	EPA TO-14A/TO-15	Ethyl Acetate
GC/MS	EPA TO-14A/TO-15	Ethylbenzene
GC/MS	EPA TO-14A/TO-15	Hexachlorobutadiene
GC/MS	EPA TO-14A/TO-15	Hexane
GC/MS	EPA TO-14A/TO-15	Isooctane (2,2,4- Trimethylpentane)
GC/MS	EPA TO-14A/TO-15	Isopropyl Alcohol
GC/MS	EPA TO-14A/TO-15	Isopropylbenzene
GC/MS	EPA TO-14A/TO-15	m & p Xylene
GC/MS	EPA TO-14A/TO-15	Methyl tert-butyl Ether (MTBE)
GC/MS	EPA TO-14A/TO-15	Methylene Chloride
GC/MS	EPA TO-14A/TO-15	Naphthalene
GC/MS	EPA TO-14A/TO-15	n-Butanol
GC/MS	EPA TO-14A/TO-15	n-Butylbenzene
GC/MS	EPA TO-14A/TO-15	n-Heptane
GC/MS	EPA TO-14A/TO-15	n-Nonane
GC/MS	EPA TO-14A/TO-15	n-Octane
GC/MS	EPA TO-14A/TO-15	n-Propylbenzene
GC/MS	EPA TO-14A/TO-15	o-Xylene
GC/MS	EPA TO-14A/TO-15	Pentane
GC/MS	EPA TO-14A/TO-15	Propene
GC/MS	EPA TO-14A/TO-15	sec-Butylbenzene

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-14A/TO-15	Styrene
GC/MS	EPA TO-14A/TO-15	tert-Butylbenzene
GC/MS	EPA TO-14A/TO-15	Tetrachloroethene
GC/MS	EPA TO-14A/TO-15	Tetrahydrofuran
GC/MS	EPA TO-14A/TO-15	Toluene
GC/MS	EPA TO-14A/TO-15	trans-1,2-Dichloroethene
GC/MS	EPA TO-14A/TO-15	trans-1,3-Dichloropropene
GC/MS	EPA TO-14A/TO-15	Trichloroethene
GC/MS	EPA TO-14A/TO-15	Trichlorofluoromethane
GC/MS	EPA TO-14A/TO-15	Vinyl Acetate
GC/MS	EPA TO-14A/TO-15	Vinyl Bromide
GC/MS	EPA TO-14A/TO-15	Vinyl Chloride
GC/MS	EPA TO-14A/TO-15	Xylenes, Total
GC-FID/TCD	ASTM1946D / EPA 3C	Carbon Dioxide
GC-FID/TCD	ASTM1946D / EPA 3C	Nitrogen
GC-FID/TCD	ASTM1946D / EPA 3C	Oxygen
GC-FID/TCD	ASTM1946D / EPA 3C	Helium
GC-FID/TCD	ASTM1946D / EPA 3C	Hydrogen
GC-FID/TCD	ASTM1946D / EPA 3C	Methane
GC-FID/TCD	ASTM1946D / EPA 3C	Carbon Monoxide
GC/MS	EPA TO-14A/TO-15	Gasoline Range Organics (GRO)
GC/MS	EPA TO-14A/TO-15	TPH as Gasoline
GC/MS SIM	EPA TO-15 SIM	1,1,1-Trichloroethane
GC/MS SIM	EPA TO-15 SIM	1,1,2,2-Tetrachloroethane
GC/MS SIM	EPA TO-15 SIM	1,1,2-Trichloroethane
GC/MS SIM	EPA TO-15 SIM	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS SIM	EPA TO-15 SIM	1,1-Dichloroethane
GC/MS SIM	EPA TO-15 SIM	1,1-Dichloroethene
GC/MS SIM	EPA TO-15 SIM	1,2,3-Trichloropropane
GC/MS SIM	EPA TO-15 SIM	1,2,4-Trichlorobenzene
GC/MS SIM	EPA TO-15 SIM	1,2-Dibromoethane
GC/MS SIM	EPA TO-15 SIM	1,2-Dichlorobenzene
GC/MS SIM	EPA TO-15 SIM	1,2-Dichloroethane
GC/MS SIM	EPA TO-15 SIM	1,2-Dichloropropane
GC/MS SIM	EPA TO-15 SIM	1,3-Dichlorobenzene
GC/MS SIM	EPA TO-15 SIM	1,4-Dichlorobenzene

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA TO-15 SIM	1,4-Dioxane
GC/MS SIM	EPA TO-15 SIM	Acrolein
GC/MS SIM	EPA TO-15 SIM	Benzene
GC/MS SIM	EPA TO-15 SIM	Benzyl Chloride
GC/MS SIM	EPA TO-15 SIM	Bromodichloromethane
GC/MS SIM	EPA TO-15 SIM	Butadiene (1,3-Butadiene)
GC/MS SIM	EPA TO-15 SIM	Carbon Tetrachloride
GC/MS SIM	EPA TO-15 SIM	Chlorobenzene
GC/MS SIM	EPA TO-15 SIM	Chloroethane
GC/MS SIM	EPA TO-15 SIM	Chloroform
GC/MS SIM	EPA TO-15 SIM	Chloromethane
GC/MS SIM	EPA TO-15 SIM	cis-1,2-Dichloroethene
GC/MS SIM	EPA TO-15 SIM	cis-1,3-Dichloropropene
GC/MS SIM	EPA TO-15 SIM	Dibromochloromethane
GC/MS SIM	EPA TO-15 SIM	Dichlorodifluoromethane
GC/MS SIM	EPA TO-15 SIM	Ethylbenzene
GC/MS SIM	EPA TO-15 SIM	Hexachlorobutadiene
GC/MS SIM	EPA TO-15 SIM	m & p Xylene
GC/MS SIM	EPA TO-15 SIM	Methyl tert-butyl Ether (MTBE)
GC/MS SIM	EPA TO-15 SIM	Methylene Chloride
GC/MS SIM	EPA TO-15 SIM	Naphthalene
GC/MS SIM	EPA TO-15 SIM	o-Xylene
GC/MS SIM	EPA TO-15 SIM	Styrene
GC/MS SIM	EPA TO-15 SIM	Tetrachloroethene
GC/MS SIM	EPA TO-15 SIM	Toluene
GC/MS SIM	EPA TO-15 SIM	trans-1,2-Dichloroethene
GC/MS SIM	EPA TO-15 SIM	trans-1,3-Dichloropropene
GC/MS SIM	EPA TO-15 SIM	Trichloroethene
GC/MS SIM	EPA TO-15 SIM	Trichlorofluoromethane
GC/MS SIM	EPA TO-15 SIM	Vinyl Chloride
GC/MS SIM	EPA TO-15 SIM	Xylenes, Total
GC/MS	EPA TO-13A	1,2,4-Trichlorobenzene
GC/MS	EPA TO-13A	1,2-Dichlorobenzene
GC/MS	EPA TO-13A	1,3-Dichlorobenzene
GC/MS	EPA TO-13A	1,3-Dinitrobenzene
GC/MS	EPA TO-13A	1,4-Dichlorobenzene

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-13A	1-Methylnaphthalene
GC/MS	EPA TO-13A	2,3,4,6-Tetrachlorophenol
GC/MS	EPA TO-13A	2,4,5-Trichlorophenol
GC/MS	EPA TO-13A	2,4,6-Trichlorophenol
GC/MS	EPA TO-13A	2,4-Dichlorophenol
GC/MS	EPA TO-13A	2,4-Dimethylphenol
GC/MS	EPA TO-13A	2,4-Dinitrophenol
GC/MS	EPA TO-13A	2,4-Dinitrotoluene
GC/MS	EPA TO-13A	2,6-Dichlorophenol
GC/MS	EPA TO-13A	2,6-Dinitrotoluene
GC/MS	EPA TO-13A	2-Chloronaphthalene
GC/MS	EPA TO-13A	2-Chlorophenol
GC/MS	EPA TO-13A	2-Methylnaphthalene
GC/MS	EPA TO-13A	2-Methylphenol
GC/MS	EPA TO-13A	2-Nitroaniline
GC/MS	EPA TO-13A	2-Nitrophenol
GC/MS	EPA TO-13A	3&4-Methylphenol
GC/MS	EPA TO-13A	3,3'-Dichlorobenzidine
GC/MS	EPA TO-13A	3-Nitroaniline
GC/MS	EPA TO-13A	4,6-Dinitro-2-methylphenol
GC/MS	EPA TO-13A	4-Bromophenyl phenyl ether
GC/MS	EPA TO-13A	4-Chloro-3-methylphenol
GC/MS	EPA TO-13A	4-Chloroaniline
GC/MS	EPA TO-13A	4-Chlorophenyl phenyl ether
GC/MS	EPA TO-13A	4-Nitroaniline
GC/MS	EPA TO-13A	4-Nitrophenol
GC/MS	EPA TO-13A	Acenaphthene
GC/MS	EPA TO-13A	Acenaphthylene
GC/MS	EPA TO-13A	Aniline
GC/MS	EPA TO-13A	Anthracene
GC/MS	EPA TO-13A	Benzo(a)anthracene
GC/MS	EPA TO-13A	Benzo(a)pyrene
GC/MS	EPA TO-13A	Benzo(b)fluoranthene
GC/MS	EPA TO-13A	Benzo(g,h,i)perylene
GC/MS	EPA TO-13A	Benzo(k)fluoranthene
GC/MS	EPA TO-13A	Benzoic Acid

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-13A	Benzyl Alcohol
GC/MS	EPA TO-13A	Benzyl butyl Phthalate
GC/MS	EPA TO-13A	Biphenyl
GC/MS	EPA TO-13A	Bis(2-chloroethoxy) Methane
GC/MS	EPA TO-13A	Bis(2-chloroethyl) Ether
GC/MS	EPA TO-13A	Bis(2-chloroisopropyl) Ether
GC/MS	EPA TO-13A	Carbazole
GC/MS	EPA TO-13A	Chrysene
GC/MS	EPA TO-13A	Bis (2-ethylhexyl) Phthalate
GC/MS	EPA TO-13A	Dibenz(a,h)anthracene
GC/MS	EPA TO-13A	Dibenzofuran
GC/MS	EPA TO-13A	Diethyl Phthalate
GC/MS	EPA TO-13A	Dimethyl Phthalate
GC/MS	EPA TO-13A	Di-n-butyl Phthalate
GC/MS	EPA TO-13A	Di-n-octyl Phthalate
GC/MS	EPA TO-13A	Fluoranthene
GC/MS	EPA TO-13A	Fluorene
GC/MS	EPA TO-13A	Hexachlorobenzene
GC/MS	EPA TO-13A	Hexachlorobutadiene
GC/MS	EPA TO-13A	Hexachlorocyclopentadiene
GC/MS	EPA TO-13A	Hexachloroethane
GC/MS	EPA TO-13A	Indeno(1,2,3-c,d) Pyrene
GC/MS	EPA TO-13A	Isophorone
GC/MS	EPA TO-13A	Naphthalene
GC/MS	EPA TO-13A	Nitrobenzene
GC/MS	EPA TO-13A	n-Nitrosodimethylamine
GC/MS	EPA TO-13A	n-Nitrosodi-n-propylamine
GC/MS	EPA TO-13A	n-Nitrosodiphenylamine
GC/MS	EPA TO-13A	Pentachlorophenol
GC/MS	EPA TO-13A	Phenanthrene
GC/MS	EPA TO-13A	Phenol
GC/MS	EPA TO-13A	Pyrene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	1-Methylnaphthalene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	2-Methylnaphthalene
GC/MS SIM	EPA TO-13A SIM /	Acenaphthene

Air and Emissions		
Technology	**Method**	**Analyte**
	WS-MS-0006	
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Acenaphthylene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Anthracene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Benzo(a)anthracene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Benzo(a)pyrene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Benzo(b)fluoranthene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Benzo(g,h,i)perylene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Benzo(k)fluoranthene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Chrysene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Fluoranthene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Fluorene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Indeno(1,2,3-c,d) Pyrene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Naphthalene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Phenanthrene
GC/MS SIM	EPA TO-13A SIM / WS-MS-0006	Pyrene
GC-ECD	EPA TO-4A/TO-10A	PCB-1016
GC-ECD	EPA TO-4A/TO-10A	PCB-1221
GC-ECD	EPA TO-4A/TO-10A	PCB-1232
GC-ECD	EPA TO-4A/TO-10A	PCB-1242
GC-ECD	EPA TO-4A/TO-10A	PCB-1248
GC-ECD	EPA TO-4A/TO-10A	PCB-1254
GC-ECD	EPA TO-4A/TO-10A	PCB-1260
GC-ECD	EPA TO-4A/TO-10A	PCB-1262
GC-ECD	EPA TO-4A/TO-10A	PCB-1268

Air and Emissions		
Technology	**Method**	**Analyte**
Preparation	**Method**	**Type**
Acid Digestion (Filters, Solid)	EPA 3050B	Inorganics
Soxhlet extraction of PUF	TO-4A/TO-10A	PCBs in Air
Soxhlet extraction of PUF/XAD	TO-13	Semivolatiles in Air
Florisil Cleanup	EPA 3620B/3620C	Cleanup of pesticide residues and other chlorinated hydrocarbons
Sulfur Cleanup	EPA 3660A	Sulfur Cleanup
Sulfuric Acid Cleanup	EPA 3665A	Sulfuric Acid Cleanup for PCBs

Note:

1. This scope is formatted as part of a single document including Certificate of Accreditation No. L2468

Vice President

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

TestAmerica Laboratories, Inc.
5755 8th Street East
Tacoma, WA 98424

has been assessed by ANAB
and meets the requirements of

ISO/IEC 17025:2005 and DoD-ELAP

while demonstrating technical competence in the field of

TESTING

Refer to the accompanying Scope of Accreditation for information regarding the types of tests to which this accreditation applies.

L2236
Certificate Number

ANAB Approval

Certificate Valid: 11/16/2017-01/19/2019
Version No. 002 Issued: 11/16/2017

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

ANSI-ASQ National Accreditation Board

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 AND DOD QUALITY SYSTEMS MAUAL FOR ENVIRONMENTAL LABORATORIES (DOD QSM V5.1)

TestAmerica Laboratories, Inc
5755 8th Street East
Tacoma, WA 98424
Terri Torres
253-922-2310

TESTING

Valid to: **January 19, 2019** Certificate Number: **L2236**

Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/6010C/200.7	Silver
ICP-AES	EPA 6010B/6010C/200.7	Aluminum
ICP-AES	EPA 6010B/6010C/200.7	Arsenic
ICP-AES	EPA 6010B/6010C/200.7	Boron
ICP-AES	EPA 6010B/6010C/200.7	Barium
ICP-AES	EPA 6010B/6010C/200.7	Beryllium
ICP-AES	EPA 6010B/6010C/200.7	Calcium
ICP-AES	EPA 6010B/6010C/200.7	Cadmium
ICP-AES	EPA 6010B/6010C/200.7	Cobalt
ICP-AES	EPA 6010B/6010C/200.7	Chromium
ICP-AES	EPA 6010B/6010C/200.7	Copper
ICP-AES	EPA 6010B/6010C/200.7	Iron
ICP-AES	EPA 6010B/6010C/200.7	Potassium
ICP-AES	EPA 6010B/6010C/200.7	Magnesium
ICP-AES	EPA 6010B/6010C/200.7	Manganese
ICP-AES	EPA 6010B/6010C/200.7	Molybdenum
ICP-AES	EPA 6010B/6010C/200.7	Sodium
ICP-AES	EPA 6010B/6010C/200.7	Nickel
ICP-AES	EPA 6010B/6010C/200.7	Lead

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/6010C/200.7	Antimony
ICP-AES	EPA 6010B/6010C/200.7	Selenium
ICP-AES	EPA 6010B/6010C/200.7	Silicon
ICP-AES	EPA 6010B/6010C/200.7	Tin
ICP-AES	EPA 6010B/6010C/200.7	Titanium
ICP-AES	EPA 6010B/6010C/200.7	Strontium
ICP-AES	EPA 6010B/6010C/200.7	Thallium
ICP-AES	EPA 6010B/6010C/200.7	Vanadium
ICP-AES	EPA 6010B/6010C/200.7	Zinc
ICP-MS	EPA 6020/6020A/200.8	Silver
ICP-MS	EPA 6020/6020A/200.8	Arsenic
ICP-MS	EPA 6020/6020A/200.8	Barium
ICP-MS	EPA 6020/6020A/200.8	Beryllium
ICP-MS	EPA 6020/6020A/200.8	Cadmium
ICP-MS	EPA 6020/6020A/200.8	Cobalt
ICP-MS	EPA 6020/6020A/200.8	Chromium
ICP-MS	EPA 6020/6020A/200.8	Copper
ICP-MS	EPA 6020/6020A/200.8	Manganese
ICP-MS	EPA 6020/6020A/200.8	Molybdenum
ICP-MS	EPA 6020/6020A/200.8	Nickel
ICP-MS	EPA 6020/6020A/200.8	Lead
ICP-MS	EPA 6020/6020A/200.8	Antimony
ICP-MS	EPA 6020/6020A/200.8	Selenium
ICP-MS	EPA 6020/6020A/200.8	Thallium
ICP-MS	EPA 6020/6020A/200.8	Uranium
ICP-MS	EPA 6020/6020A/200.8	Vanadium
ICP-MS	EPA 6020/6020A/200.8	Zinc
CVAAS	EPA 7470A/245.1	Mercury
GC/MS	EPA 8260B/8260C/624	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C/624	1,1,1-Trichloroethane
GC/MS	EPA 8260B/8260C/624	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C/624	1,1,2-Trichloroethane
GC/MS	EPA 8260B/8260C/624	1,1-Dichloroethane
GC/MS	EPA 8260B/8260C/624	1,1-Dichloroethene
GC/MS	EPA 8260B/8260C/624	1,1-Dichloropropene
GC/MS	EPA 8260B/8260C/624	1,2,3-Trichlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C/624	1,2,3-Trichloropropane
GC/MS	EPA 8260B/8260C/624	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/8260C/624	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/8260C/624	1,2-Dibromo-3-Chloropropane
GC/MS	EPA 8260B/8260C/624	1,2-Dichlorobenzene
GC/MS	EPA 8260B/8260C/624	1,2-Dichloroethane
GC/MS	EPA 8260B/8260C/624	1,2-Dichloropropane
GC/MS	EPA 8260B/8260C/624	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/8260C/624	1,3-Dichloropropane
GC/MS	EPA 8260B/8260C/624	1,4-Dichlorobenzene
GC/MS	EPA 8260B/8260C/624	2,2-Dichloropropane
GC/MS	EPA 8260B/8260C/624	2-Chloroethylvinylether
GC/MS	EPA 8260B/8260C/624	2-Chlorotoluene
GC/MS	EPA 8260B/8260C/624	2-Hexanone
GC/MS	EPA 8260B/8260C/624	4-Chlorotoluene
GC/MS	EPA 8260B/8260C/624	4-Isopropyltoluene
GC/MS	EPA 8260B/8260C/624	Acetone
GC/MS	EPA 8260B/8260C/624	Acetonitrile
GC/MS	EPA 8260B/8260C/624	Acrolein
GC/MS	EPA 8260B/8260C/624	Acrylonitrile
GC/MS	EPA 8260B/8260C/624	Benzene
GC/MS	EPA 8260B/8260C/624	Bromobenzene
GC/MS	EPA 8260B/8260C/624	Bromodichloromethane
GC/MS	EPA 8260B/8260C/624	Bromoform
GC/MS	EPA 8260B/8260C/624	Bromomethane
GC/MS	EPA 8260B/8260C/624	Carbon disulfide
GC/MS	EPA 8260B/8260C/624	Carbon tetrachloride
GC/MS	EPA 8260B/8260C/624	Chlorobenzene
GC/MS	EPA 8260B/8260C/624	Chlorobromomethane
GC/MS	EPA 8260B/8260C/624	Chlorodibromomethane
GC/MS	EPA 8260B/8260C/624	Chloroethane
GC/MS	EPA 8260B/8260C/624	Chloroform
GC/MS	EPA 8260B/8260C/624	Chloromethane
GC/MS	EPA 8260B/8260C/624	cis-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C/624	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C/624	Dibromomethane

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C/624	Dichlorodifluoromethane
GC/MS	EPA 8260B/8260C/624	Ethylbenzene
GC/MS	EPA 8260B/8260C/624	Ethylene Dibromide
GC/MS	EPA 8260B/8260C/624	Hexachlorobutadiene
GC/MS	EPA 8260B/8260C/624	Isopropylbenzene
GC/MS	EPA 8260B/8260C/624	Methyl Ethyl Ketone
GC/MS	EPA 8260B/8260C/624	Methyl Isobutyl Ketone
GC/MS	EPA 8260B/8260C/624	Methyl tert-butyl ether
GC/MS	EPA 8260B/8260C/624	Methylene Chloride
GC/MS	EPA 8260B/8260C/624	m-Xylene & p-Xylene
GC/MS	EPA 8260B/8260C/624	Naphthalene
GC/MS	EPA 8260B/8260C/624	n-Butylbenzene
GC/MS	EPA 8260B/8260C/624	N-Propylbenzene
GC/MS	EPA 8260B/8260C/624	o-Xylene
GC/MS	EPA 8260B/8260C/624	sec-Butylbenzene
GC/MS	EPA 8260B/8260C/624	Styrene
GC/MS	EPA 8260B/8260C/624	tert-Butylbenzene
GC/MS	EPA 8260B/8260C/624	Tetrachloroethene
GC/MS	EPA 8260B/8260C/624	Toluene
GC/MS	EPA 8260B/8260C/624	trans-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C/624	trans-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C/624	Trichloroethene
GC/MS	EPA 8260B/8260C/624	Trichlorofluoromethane
GC/MS	EPA 8260B/8260C/624	Vinyl Acetate
GC/MS	EPA 8260B/8260C/624	Vinyl chloride
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1,1,2-Tetrachloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1,2,2-Tetrachloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1,2-Trichloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1-Dichloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,2-Dichloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,4-Dichlorobenzene
GC/MS SIM	EPA 8260B SIM	2-Hexanone

Non-Potable Water		
Technology	**Method**	**Analyte**
	EPA 8260C SIM	
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Benzene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Bromoform
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Bromomethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Butadiene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Chlorodibromomethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Chloroform
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	cis-1,2-Dichloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	cis-1,3-Dichloropropene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Dibromomethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Bromodichloromethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Ethylene Dibromide
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Hexachlorobutadiene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Isopropyl alcohol
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Naphthalene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Tetrachloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	trans-1,3-Dichloropropene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Trichloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Vinyl chloride
GC/MS	EPA 8270C/8270D/625	1-Methylnaphthalene
GC/MS	EPA 8270C/8270D/625	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/8270D/625	1,2-Dichlorobenzene
GC/MS	EPA 8270C/8270D/625	1,3-Dichlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D/625	1,4-Dichlorobenzene
GC/MS	EPA 8270C/8270D/625	bis(2-chloroisopropyl)ether
GC/MS	EPA 8270C/8270D/625	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/8270D/625	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/8270D/625	2,4,6-Trichlorophenol
GC/MS	EPA 8270C/8270D/625	2,4-Dichlorophenol
GC/MS	EPA 8270C/8270D/625	2,4-Dimethylphenol
GC/MS	EPA 8270C/8270D/625	2,4-Dinitrophenol
GC/MS	EPA 8270C/8270D/625	2,4-Dinitrotoluene
GC/MS	EPA 8270C/8270D/625	2,6-Dinitrotoluene
GC/MS	EPA 8270C/8270D/625	2-Chloronaphthalene
GC/MS	EPA 8270C/8270D/625	2-Chlorophenol
GC/MS	EPA 8270C/8270D/625	2-Methylnaphthalene
GC/MS	EPA 8270C/8270D/625	2-Methylphenol
GC/MS	EPA 8270C/8270D/625	2-Nitroaniline
GC/MS	EPA 8270C/8270D/625	2-Nitrophenol
GC/MS	EPA 8270C/8270D/625	3 & 4 Methylphenol
GC/MS	EPA 8270C/8270D/625	3,3'-Dichlorobenzidine
GC/MS	EPA 8270C/8270D/625	3-Nitroaniline
GC/MS	EPA 8270C/8270D/625	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270C/8270D/625	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/8270D/625	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/8270D/625	4-Chloroaniline
GC/MS	EPA 8270C/8270D/625	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/8270D/625	4-Nitroaniline
GC/MS	EPA 8270C/8270D/625	4-Nitrophenol
GC/MS	EPA 8270C/8270D/625	Acenaphthene
GC/MS	EPA 8270C/8270D/625	Acenaphthylene
GC/MS	EPA 8270C/8270D/625	Aniline
GC/MS	EPA 8270C/8270D/625	Anthracene
GC/MS	EPA 8270C/8270D/625	1,2-Diphenylhydrazine as Azobenzene
GC/MS	EPA 8270C/8270D/625	Benzo[a]anthracene
GC/MS	EPA 8270C/8270D/625	Benzo[a]pyrene
GC/MS	EPA 8270C/8270D/625	Benzo[b]fluoranthene
GC/MS	EPA 8270C/8270D/625	Benzo[g,h,i]perylene
GC/MS	EPA 8270C/8270D/625	Benzo[k]fluoranthene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D/625	Benzoic acid
GC/MS	EPA 8270C/8270D/625	Benzyl alcohol
GC/MS	EPA 8270C/8270D/625	Bis(2-chloroethoxy)methane
GC/MS	EPA 8270C/8270D/625	Bis(2-chloroethyl)ether
GC/MS	EPA 8270C/8270D/625	Bis(2-ethylhexyl) phthalate
GC/MS	EPA 8270C/8270D/625	Butyl benzyl phthalate
GC/MS	EPA 8270C/8270D/625	Carbazole
GC/MS	EPA 8270C/8270D/625	Chrysene
GC/MS	EPA 8270C/8270D/625	Dibenz(a,h)anthracene
GC/MS	EPA 8270C/8270D/625	Dibenzofuran
GC/MS	EPA 8270C/8270D/625	Diethyl phthalate
GC/MS	EPA 8270C/8270D/625	Dimethyl phthalate
GC/MS	EPA 8270C/8270D/625	Di-n-butyl phthalate
GC/MS	EPA 8270C/8270D/625	Di-n-octyl phthalate
GC/MS	EPA 8270C/8270D/625	Fluoranthene
GC/MS	EPA 8270C/8270D/625	Fluorene
GC/MS	EPA 8270C/8270D/625	Hexachlorobenzene
GC/MS	EPA 8270C/8270D/625	Hexachlorobutadiene
GC/MS	EPA 8270C/8270D/625	Hexachlorocyclopentadiene
GC/MS	EPA 8270C/8270D/625	Hexachloroethane
GC/MS	EPA 8270C/8270D/625	Indeno[1,2,3-cd]pyrene
GC/MS	EPA 8270C/8270D/625	Isophorone
GC/MS	EPA 8270C/8270D/625	Naphthalene
GC/MS	EPA 8270C/8270D/625	Nitrobenzene
GC/MS	EPA 8270C/8270D/625	N-Nitrosodimethylamine
GC/MS	EPA 8270C/8270D/625	N-Nitrosodi-n-propylamine
GC/MS	EPA 8270C/8270D/625	N-Nitrosodiphenylamine
GC/MS	EPA 8270C/8270D/625	Pentachlorophenol
GC/MS	EPA 8270C/8270D/625	Phenanthrene
GC/MS	EPA 8270C/8270D/625	Phenol
GC/MS	EPA 8270C/8270D/625	Pyrene
GC/MS	EPA 8270C/8270D/625	Pyridine
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	1-Methylnaphthalene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	1,3-Dinitrobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	1,4-Dioxane
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2-Methylnaphthalene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,4,6-Trichlorophenol
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,4-Dinitrophenol
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,4-Dinitrotoluene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,6-Dinitrotoluene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Acenaphthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Acenaphthylene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Anthracene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[a]anthracene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[a]pyrene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[b]fluoranthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[g,h,i]perylene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[k]fluoranthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Bis(2-chloroethyl)ether
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Chrysene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Dibenz(a,h)anthracene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Fluoranthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Fluorene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachlorobenzene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachlorobutadiene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachlorocyclopentadiene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachloroethane
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Indeno[1,2,3-cd]pyrene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Naphthalene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Nitrobenzene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	N-Nitrosodimethylamine
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	N-Nitrosodi-n-propylamine
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Pentachlorophenol
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Phenanthrene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Pyrene
GC-ECD	EPA 8011/504.1	1,2-Dibromoethane
GC-ECD	EPA 8011/504.1	1,2-Dibromo-3-Chloropropane
GC-ECD	EPA 8011/504.1	1,2,3-Trichloropropane
GC-ECD	EPA 8081A/8081B/608	4,4'-DDD
GC-ECD	EPA 8081A/8081B/608	4,4'-DDE
GC-ECD	EPA 8081A/8081B/608	4,4'-DDT
GC-ECD	EPA 8081A/8081B/608	Aldrin
GC-ECD	EPA 8081A/8081B/608	alpha-BHC
GC-ECD	EPA 8081A/8081B/608	alpha-Chlordane
GC-ECD	EPA 8081A/8081B/608	beta-BHC
GC-ECD	EPA 8081A/8081B/608	delta-BHC
GC-ECD	EPA 8081A/8081B/608	Dieldrin
GC-ECD	EPA 8081A/8081B/608	Endosulfan I
GC-ECD	EPA 8081A/8081B/608	Endosulfan II
GC-ECD	EPA 8081A/8081B/608	Endosulfan sulfate
GC-ECD	EPA 8081A/8081B/608	Endrin
GC-ECD	EPA 8081A/8081B/608	Endrin aldehyde
GC-ECD	EPA 8081A/8081B/608	Endrin ketone
GC-ECD	EPA 8081A/8081B/608	gamma-BHC (Lindane)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-ECD	EPA 8081A/8081B/608	gamma-Chlordane
GC-ECD	EPA 8081A/8081B/608	Heptachlor
GC-ECD	EPA 8081A/8081B/608	Heptachlor epoxide
GC-ECD	EPA 8081A/8081B/608	Methoxychlor
GC-ECD	EPA 8081A/8081B/608	Technical Chlordane
GC-ECD	EPA 8081A/8081B/608	Toxaphene
GC-ECD	EPA 8082/8082A/608	PCB-1016
GC-ECD	EPA 8082/8082A/608	PCB-1221
GC-ECD	EPA 8082/8082A/608	PCB-1232
GC-ECD	EPA 8082/8082A/608	PCB-1242
GC-ECD	EPA 8082/8082A/608	PCB-1248
GC-ECD	EPA 8082/8082A/608	PCB-1254
GC-ECD	EPA 8082/8082A/608	PCB-1260
GC-ECD	EPA 8082/8082A/608	PCB-1262
GC-ECD	EPA 8082/8082A/608	PCB-1268
GC-IT/MS	EPA 8151A MOD	2,4,5-T
GC-IT/MS	EPA 8151A MOD	2,4-D
GC-IT/MS	EPA 8151A MOD	2,4-DB
GC-IT/MS	EPA 8151A MOD	4-Nitrophenol
GC-IT/MS	EPA 8151A MOD	Dalapon
GC-IT/MS	EPA 8151A MOD	Dicamba
GC-IT/MS	EPA 8151A MOD	Dichlorprop
GC-IT/MS	EPA 8151A MOD	Dinoseb
GC-IT/MS	EPA 8151A MOD	MCPA
GC-IT/MS	EPA 8151A MOD	Mecoprop
GC-IT/MS	EPA 8151A MOD	Pentachlorophenol
GC-IT/MS	EPA 8151A MOD	Silvex (2,4,5-TP)
GC-FID	EPA 8015B	Gasoline
GC-FID	AK101	Gasoline
GC-FID	NWTPH-Gx	Gasoline
GC-FID	NWVPH	Volatile Petroleum Hydrocarbons
GC-FID	EPA 8015B	Diesel
GC-FID	AK102	Diesel
GC-FID	NWTPH-Dx	Diesel
GC-FID	NWEPH	Extractable Petroleum Hydrocarbons
GC-FID	EPA 8015B	Motor Oil

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-FID	AK103	Motor Oil
GC-FID	NWTPH-Dx	Motor Oil
Titration	EPA 310.1 / SM 2320B	Alkalinity
Colorimetric / RFA	EPA 353.2	Nitrate
Colorimetric / RFA	EPA 353.2	Nitrite
Colorimetric / RFA	EPA 353.2	Nitrate + Nitrite
Probe	EPA 405.1 / SM 5210B	BOD
Titration	EPA 410.2 SM 5220C	COD
Colorimetric / RFA	SM 5220D 21st Ed	COD
Gravimetric	EPA 1664A	Oil & Grease
Colorimetric/RFA	EPA 9012A	Total Cyanides
Colorimetric	EPA 7196A	Hexavalent Chromium
Ion Chromatography	EPA 300.0/9056A	Bromide
Ion Chromatography	EPA 300.0/9056A	Chloride
Ion Chromatography	EPA 300.0/9056A	Fluoride
Ion Chromatography	EPA 300.0/9056A	Sulfate
Ion Chromatography	EPA 300.0/9056A	Nitrate
Ion Chromatography	EPA 300.0/9056A	Nitrite
TOC Analyzer (IR)	EPA 415.1/9060	TOC
Probe	EPA 9040B/9045C/150.1	pH
Conductivity meter	EPA 9050A/120.1 SM 2510B	Specific Conductance
Setaflash	EPA 1020A	Flashpoint
Preparation	**Method**	**Type**
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	Semivolatile and Nonvolatile Organics
Continuous Liquid-Liquid Extraction	EPA 3520C	Semivolatile and Nonvolatile Organics
Purge and Trap	EPA 5030B	Volatile Organic Compounds
Acid Digestion (Aqueous)	EPA 3005A/3010A	Inorganics
TCLP Extraction	EPA 1311	Toxicity Characteristic Leaching Procedure
Florisil Cleanup	EPA 3620B	Cleanup of pesticide residues and other chlorinated hydrocarbons
Silica Gel Cleanup	EPA 3630C	Column Cleanup

Non-Potable Water		
Technology	**Method**	**Analyte**
Sulfur Cleanup	EPA 3660B	Sulfur Cleanup Reagent
Sulfuric Acid Cleanup	EPA 3665A	Cleanup for Quantization of PCBs

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/6010C	Silver
ICP-AES	EPA 6010B/6010C	Aluminum
ICP-AES	EPA 6010B/6010C	Arsenic
ICP-AES	EPA 6010B/6010C	Boron
ICP-AES	EPA 6010B/6010C	Barium
ICP-AES	EPA 6010B/6010C	Beryllium
ICP-AES	EPA 6010B/6010C	Calcium
ICP-AES	EPA 6010B/6010C	Cadmium
ICP-AES	EPA 6010B/6010C	Cobalt
ICP-AES	EPA 6010B/6010C	Chromium
ICP-AES	EPA 6010B/6010C	Copper
ICP-AES	EPA 6010B/6010C	Iron
ICP-AES	EPA 6010B/6010C	Potassium
ICP-AES	EPA 6010B/6010C	Magnesium
ICP-AES	EPA 6010B/6010C	Manganese
ICP-AES	EPA 6010B/6010C	Molybdenum
ICP-AES	EPA 6010B/6010C	Sodium
ICP-AES	EPA 6010B/6010C	Nickel
ICP-AES	EPA 6010B/6010C	Lead
ICP-AES	EPA 6010B/6010C	Antimony
ICP-AES	EPA 6010B/6010C	Selenium
ICP-AES	EPA 6010B/6010C	Silicon
ICP-AES	EPA 6010B/6010C	Tin
ICP-AES	EPA 6010B/6010C	Titanium
ICP-AES	EPA 6010B/6010C	Strontium
ICP-AES	EPA 6010B/6010C	Thallium
ICP-AES	EPA 6010B/6010C	Vanadium
ICP-AES	EPA 6010B/6010C	Zinc
ICP-MS	EPA 6020/6020A	Silver

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/6020A	Arsenic
ICP-MS	EPA 6020/6020A	Barium
ICP-MS	EPA 6020/6020A	Beryllium
ICP-MS	EPA 6020/6020A	Cadmium
ICP-MS	EPA 6020/6020A	Cobalt
ICP-MS	EPA 6020/6020A	Chromium
ICP-MS	EPA 6020/6020A	Copper
ICP-MS	EPA 6020/6020A	Manganese
ICP-MS	EPA 6020/6020A	Molybdenum
ICP-MS	EPA 6020/6020A	Nickel
ICP-MS	EPA 6020/6020A	Lead
ICP-MS	EPA 6020/6020A	Antimony
ICP-MS	EPA 6020/6020A	Selenium
ICP-MS	EPA 6020/6020A	Thallium
ICP-MS	EPA 6020/6020A	Uranium
ICP-MS	EPA 6020/6020A	Vanadium
ICP-MS	EPA 6020/6020A	Zinc
CVAAS	EPA 7471A	Mercury
GC/MS	EPA 8260B/8260C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C	1,1,1-Trichloroethane
GC/MS	EPA 8260B/8260C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/8260C	1,1,2-Trichloroethane
GC/MS	EPA 8260B/8260C	1,1-Dichloroethane
GC/MS	EPA 8260B/8260C	1,1-Dichloroethene
GC/MS	EPA 8260B/8260C	1,1-Dichloropropene
GC/MS	EPA 8260B/8260C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/8260C	1,2,3-Trichloropropane
GC/MS	EPA 8260B/8260C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/8260C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/8260C	1,2-Dibromo-3-Chloropropane
GC/MS	EPA 8260B/8260C	1,2-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1,2-Dichloroethane
GC/MS	EPA 8260B/8260C	1,2-Dichloropropane
GC/MS	EPA 8260B/8260C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/8260C	1,3-Dichlorobenzene
GC/MS	EPA 8260B/8260C	1,3-Dichloropropane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C	1,4-Dichlorobenzene
GC/MS	EPA 8260B/8260C	2,2-Dichloropropane
GC/MS	EPA 8260B/8260C	2-Chloroethylvinylether
GC/MS	EPA 8260B/8260C	2-Chlorotoluene
GC/MS	EPA 8260B/8260C	2-Hexanone
GC/MS	EPA 8260B/8260C	4-Chlorotoluene
GC/MS	EPA 8260B/8260C	4-Isopropyltoluene
GC/MS	EPA 8260B/8260C	Acetone
GC/MS	EPA 8260B/8260C	Acetonitrile
GC/MS	EPA 8260B/8260C	Acrolein
GC/MS	EPA 8260B/8260C	Acrylonitrile
GC/MS	EPA 8260B/8260C	Benzene
GC/MS	EPA 8260B/8260C	Bromobenzene
GC/MS	EPA 8260B/8260C	Bromodichloromethane
GC/MS	EPA 8260B/8260C	Bromoform
GC/MS	EPA 8260B/8260C	Bromomethane
GC/MS	EPA 8260B/8260C	Carbon disulfide
GC/MS	EPA 8260B/8260C	Carbon tetrachloride
GC/MS	EPA 8260B/8260C	Chlorobenzene
GC/MS	EPA 8260B/8260C	Chlorobromomethane
GC/MS	EPA 8260B/8260C	Chlorodibromomethane
GC/MS	EPA 8260B/8260C	Chloroethane
GC/MS	EPA 8260B/8260C	Chloroform
GC/MS	EPA 8260B/8260C	Chloromethane
GC/MS	EPA 8260B/8260C	cis-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C	Dibromomethane
GC/MS	EPA 8260B/8260C	Dichlorodifluoromethane
GC/MS	EPA 8260B/8260C	Ethylbenzene
GC/MS	EPA 8260B/8260C	Ethylene Dibromide
GC/MS	EPA 8260B/8260C	Hexachlorobutadiene
GC/MS	EPA 8260B/8260C	Isopropylbenzene
GC/MS	EPA 8260B/8260C	Methyl Ethyl Ketone
GC/MS	EPA 8260B/8260C	Methyl Isobutyl Ketone
GC/MS	EPA 8260B/8260C	Methyl tert-butyl ether
GC/MS	EPA 8260B/8260C	Methylene Chloride

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/8260C	m-Xylene & p-Xylene
GC/MS	EPA 8260B/8260C	Naphthalene
GC/MS	EPA 8260B/8260C	n-Butylbenzene
GC/MS	EPA 8260B/8260C	N-Propylbenzene
GC/MS	EPA 8260B/8260C	o-Xylene
GC/MS	EPA 8260B/8260C	sec-Butylbenzene
GC/MS	EPA 8260B/8260C	Styrene
GC/MS	EPA 8260B/8260C	tert-Butylbenzene
GC/MS	EPA 8260B/8260C	Tetrachloroethene
GC/MS	EPA 8260B/8260C	Toluene
GC/MS	EPA 8260B/8260C	trans-1,2-Dichloroethene
GC/MS	EPA 8260B/8260C	trans-1,3-Dichloropropene
GC/MS	EPA 8260B/8260C	Trichloroethene
GC/MS	EPA 8260B/8260C	Trichlorofluoromethane
GC/MS	EPA 8260B/8260C	Vinyl Acetate
GC/MS	EPA 8260B/8260C	Vinyl chloride
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1,1,2-Tetrachloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1,2,2-Tetrachloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1,2-Trichloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,1-Dichloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,2-Dichloroethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	1,4-Dichlorobenzene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	2-Hexanone
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Benzene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Bromoform
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Bromomethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Butadiene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Chlorodibromomethane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Chloroform
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	cis-1,2-Dichloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	cis-1,3-Dichloropropene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Dibromomethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Bromodichloromethane
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Ethylene Dibromide
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Hexachlorobutadiene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Isopropyl alcohol
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Naphthalene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Tetrachloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	trans-1,3-Dichloropropene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Trichloroethene
GC/MS SIM	EPA 8260B SIM EPA 8260C SIM	Vinyl chloride
GC/MS	EPA 8270C/8270D	1-Methylnaphthalene
GC/MS	EPA 8270C/8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/8270D	1,2-Dichlorobenzene
GC/MS	EPA 8270C/8270D	1,3-Dichlorobenzene
GC/MS	EPA 8270C/8270D	1,4-Dichlorobenzene
GC/MS	EPA 8270C/8270D	bis(2-chloroisopropyl)ether
GC/MS	EPA 8270C/8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270C/8270D	2,4-Dichlorophenol
GC/MS	EPA 8270C/8270D	2,4-Dimethylphenol
GC/MS	EPA 8270C/8270D	2,4-Dinitrophenol
GC/MS	EPA 8270C/8270D	2,4-Dinitrotoluene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D	2,6-Dinitrotoluene
GC/MS	EPA 8270C/8270D	2-Chloronaphthalene
GC/MS	EPA 8270C/8270D	2-Chlorophenol
GC/MS	EPA 8270C/8270D	2-Methylnaphthalene
GC/MS	EPA 8270C/8270D	2-Methylphenol
GC/MS	EPA 8270C/8270D	2-Nitroaniline
GC/MS	EPA 8270C/8270D	2-Nitrophenol
GC/MS	EPA 8270C/8270D	3 & 4 Methylphenol
GC/MS	EPA 8270C/8270D	3,3'-Dichlorobenzidine
GC/MS	EPA 8270C/8270D	3-Nitroaniline
GC/MS	EPA 8270C/8270D	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270C/8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/8270D	4-Chloroaniline
GC/MS	EPA 8270C/8270D	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/8270D	4-Nitroaniline
GC/MS	EPA 8270C/8270D	4-Nitrophenol
GC/MS	EPA 8270C/8270D	Acenaphthene
GC/MS	EPA 8270C/8270D	Acenaphthylene
GC/MS	EPA 8270C/8270D	Aniline
GC/MS	EPA 8270C/8270D	Anthracene
GC/MS	EPA 8270C/8270D	1,2-Diphenylhydrazine as Azobenzene
GC/MS	EPA 8270C/8270D	Benzo[a]anthracene
GC/MS	EPA 8270C/8270D	Benzo[a]pyrene
GC/MS	EPA 8270C/8270D	Benzo[b]fluoranthene
GC/MS	EPA 8270C/8270D	Benzo[g,h,i]perylene
GC/MS	EPA 8270C/8270D	Benzo[k]fluoranthene
GC/MS	EPA 8270C/8270D	Benzoic acid
GC/MS	EPA 8270C/8270D	Benzyl alcohol
GC/MS	EPA 8270C/8270D	Bis(2-chloroethoxy)methane
GC/MS	EPA 8270C/8270D	Bis(2-chloroethyl)ether
GC/MS	EPA 8270C/8270D	Bis(2-ethylhexyl) phthalate
GC/MS	EPA 8270C/8270D	Butyl benzyl phthalate
GC/MS	EPA 8270C/8270D	Carbazole
GC/MS	EPA 8270C/8270D	Chrysene
GC/MS	EPA 8270C/8270D	Dibenz(a,h)anthracene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/8270D	Dibenzofuran
GC/MS	EPA 8270C/8270D	Diethyl phthalate
GC/MS	EPA 8270C/8270D	Dimethyl phthalate
GC/MS	EPA 8270C/8270D	Di-n-butyl phthalate
GC/MS	EPA 8270C/8270D	Di-n-octyl phthalate
GC/MS	EPA 8270C/8270D	Fluoranthene
GC/MS	EPA 8270C/8270D	Fluorene
GC/MS	EPA 8270C/8270D	Hexachlorobenzene
GC/MS	EPA 8270C/8270D	Hexachlorobutadiene
GC/MS	EPA 8270C/8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270C/8270D	Hexachloroethane
GC/MS	EPA 8270C/8270D	Indeno[1,2,3-cd]pyrene
GC/MS	EPA 8270C/8270D	Isophorone
GC/MS	EPA 8270C/8270D	Naphthalene
GC/MS	EPA 8270C/8270D	Nitrobenzene
GC/MS	EPA 8270C/8270D	N-Nitrosodimethylamine
GC/MS	EPA 8270C/8270D	N-Nitrosodi-n-propylamine
GC/MS	EPA 8270C/8270D	N-Nitrosodiphenylamine
GC/MS	EPA 8270C/8270D	Pentachlorophenol
GC/MS	EPA 8270C/8270D	Phenanthrene
GC/MS	EPA 8270C/8270D	Phenol
GC/MS	EPA 8270C/8270D	Pyrene
GC/MS	EPA 8270C/8270D	Pyridine
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	1-Methylnaphthalene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	1,3-Dinitrobenzene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	1,4-Dioxane
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2-Methylnaphthalene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,4,6-Trichlorophenol
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,4-Dinitrophenol
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,4-Dinitrotoluene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	2,6-Dinitrotoluene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	3,3'-Dichlorobenzidine
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	4-Chloroaniline
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Acenaphthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Acenaphthylene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Anthracene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[a]anthracene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[a]pyrene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[b]fluoranthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[g,h,i]perylene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Benzo[k]fluoranthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Bis(2-chloroethyl)ether
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Chrysene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Dibenz(a,h)anthracene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Fluoranthene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Fluorene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachlorobenzene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachlorobutadiene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachlorocyclopentadiene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Hexachloroethane
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Indeno[1,2,3-cd]pyrene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Naphthalene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Nitrobenzene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	N-Nitrosodimethylamine
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	N-Nitrosodi-n-propylamine
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Pentachlorophenol
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Phenanthrene
GC/MS SIM	EPA 8270C SIM EPA 8270D SIM	Pyrene
GC-ECD	EPA 8011	1,2-Dibromoethane
GC-ECD	EPA 8011	1,2-Dibromo-3-Chloropropane
GC-ECD	EPA 8011	1,2,3-Trichloropropane
GC-ECD	EPA 8081A/8081B	4,4'-DDD
GC-ECD	EPA 8081A/8081B	4,4'-DDE
GC-ECD	EPA 8081A/8081B	4,4'-DDT
GC-ECD	EPA 8081A/8081B	Aldrin
GC-ECD	EPA 8081A/8081B	alpha-BHC
GC-ECD	EPA 8081A/8081B	alpha-Chlordane
GC-ECD	EPA 8081A/8081B	beta-BHC
GC-ECD	EPA 8081A/8081B	delta-BHC
GC-ECD	EPA 8081A/8081B	Dieldrin
GC-ECD	EPA 8081A/8081B	Endosulfan I
GC-ECD	EPA 8081A/8081B	Endosulfan II
GC-ECD	EPA 8081A/8081B	Endosulfan sulfate
GC-ECD	EPA 8081A/8081B	Endrin
GC-ECD	EPA 8081A/8081B	Endrin aldehyde
GC-ECD	EPA 8081A/8081B	Endrin ketone
GC-ECD	EPA 8081A/8081B	gamma-BHC (Lindane)
GC-ECD	EPA 8081A/8081B	gamma-Chlordane
GC-ECD	EPA 8081A/8081B	Heptachlor
GC-ECD	EPA 8081A/8081B	Heptachlor epoxide
GC-ECD	EPA 8081A/8081B	Methoxychlor
GC-ECD	EPA 8081A/8081B	Technical Chlordane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-ECD	EPA 8081A/8081B	Toxaphene
GC-ECD	EPA 8082/8082A	PCB-1016
GC-ECD	EPA 8082/8082A	PCB-1221
GC-ECD	EPA 8082/8082A	PCB-1232
GC-ECD	EPA 8082/8082A	PCB-1242
GC-ECD	EPA 8082/8082A	PCB-1248
GC-ECD	EPA 8082/8082A	PCB-1254
GC-ECD	EPA 8082/8082A	PCB-1260
GC-ECD	EPA 8082/8082A	PCB-1262
GC-ECD	EPA 8082/8082A	PCB-1268
GC-IT/MS	EPA 8151A MOD	2,4,5-T
GC-IT/MS	EPA 8151A MOD	2,4-D
GC-IT/MS	EPA 8151A MOD	2,4-DB
GC-IT/MS	EPA 8151A MOD	4-Nitrophenol
GC-IT/MS	EPA 8151A MOD	Dalapon
GC-IT/MS	EPA 8151A MOD	Dicamba
GC-IT/MS	EPA 8151A MOD	Dichlorprop
GC-IT/MS	EPA 8151A MOD	Dinoseb
GC-IT/MS	EPA 8151A MOD	MCPA
GC-IT/MS	EPA 8151A MOD	Mecoprop MCPP
GC-IT/MS	EPA 8151A MOD	Pentachlorophenol
GC-IT/MS	EPA 8151A MOD	Silvex (2,4,5-TP)
GC-FID	EPA 8015B	Gasoline
GC-FID	AK101	Gasoline
GC-FID	NWTPH-Gx	Gasoline
GC-FID	NWVPH	Volatile Petroleum Hydrocarbons
GC-FID	EPA 8015B	Diesel
GC-FID	AK102	Diesel
GC-FID	NWTPH-Dx	Diesel
GC-FID	NWEPH	Extractable Petroleum Hydrocarbons
GC-FID	EPA 8015B	Motor Oil
GC-FID	AK103	Motor Oil
GC-FID	NWTPH-Dx	Motor Oil
Colorimetric/RFA	EPA 9012A	Total Cyanides
Ion Chromatography	EPA 300.0/9056A	Bromide

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
Ion Chromatography	EPA 300.0/9056A	Chloride
Ion Chromatography	EPA 300.0/9056A	Fluoride
Ion Chromatography	EPA 300.0/9056A	Sulfate
Ion Chromatography	EPA 300.0/9056A	Nitrate
Ion Chromatography	EPA 300.0/9056A	Nitrite
TOC Analyzer (IR)	EPA 9060	TOC
Probe	EPA 9040B/9045C	pH/Corrosivity
Conductivity meter	EPA 9050A	Specific Conductance
Setaflash	EPA 1020A	Flashpoint
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	Semivolatile and Nonvolatile Organics
Continuous Liquid-Liquid Extraction	EPA 3520C	Semivolatile and Nonvolatile Organics
Microwave Extraction	EPA 3546	Semivolatile and Nonvolatile Organics
Ultrasonic Extraction	EPA 3550B	Semivolatile and Nonvolatile Organics
Solvent Dilution	EPA 3580A	Semivolatile and Nonvolatile Organics
Waste Dilution	EPA 3585	Volatile Organic Compounds
Purge and Trap	EPA 5030B	Volatile Organic Compounds
Purge and Trap	EPA 5035A	Volatile Organic Compounds
Acid Digestion (Aqueous)	EPA 3005A/3010A	Inorganics
Acid Digestion (Sediments, Sludges, Soils)	EPA 3050B	Inorganics
TCLP Extraction	EPA 1311	Toxicity Characteristic Leaching Procedure
Florisil Cleanup	EPA 3620B	Cleanup of pesticide residues and other chlorinated hydrocarbons
Silica Gel Cleanup	EPA 3630C	Column Cleanup
Sulfur Cleanup	EPA 3660B	Sulfur Cleanup Reagent
Sulfuric Acid Cleanup	EPA 3665A	Cleanup for Quantitation of PCBs

Note:

1. This scope is formatted as part of a single document including Certificate of Accreditation No. L2236

Vice President

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

Alpha Analytical Inc.
320 Forbes Blvd.
Mansfield, MA 02048

has been assessed by ANAB
and meets the requirements of

ISO/IEC 17025:2005 and DoD-ELAP

while demonstrating technical competence in the field of

TESTING

Refer to the accompanying Scope of Accreditation for information regarding the types of tests to which this accreditation applies.

L2474
Certificate Number

ANAB Approval

Certificate Valid: 12/06/2017-05/30/2019
Version No. 003 Issued: 12/06/2017

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 AND DOD QUALITY SYSTEMS MAUAL FOR ENVIRONMENTAL LABORATORIES (DOD QSM V5.1)

Alpha Analytical, Inc.
320 Forbes Blvd
Mansfield, MA 02048
James Todaro
508-898-9220

TESTING

Valid to: **May 30, 2019** Certificate Number: **L2474**

Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#1-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#2
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#3-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#4/#10-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#9
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#7
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#6
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#5
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#8
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#19-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#14
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#30
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#18
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#11
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#17
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#12
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#27
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#13
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#24

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#16
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#32
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#15-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#34
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#23
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#54-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#29-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#50-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#26
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#25
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#53
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#-31
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#28
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#33
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#21/#20
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#51
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#45
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#22
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#73/#46
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#69
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#43
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#36
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#52
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#48
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#49
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#104-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#47
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#65/#75/#62
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#39
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#38
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#44
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#59
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#42
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#71
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#35
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#41

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#72
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#96
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#103
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#68/#64
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#40
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#37-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#100
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#94
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#57
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#67/#58
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#102
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#61
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#98
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#76
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#93
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#63
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#121
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#95/#88
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#74
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#155-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#70
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#66
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#91
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#80
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#55
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#92
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#89/#84
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#101/#90
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#56
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#113
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#99
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#150
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#60
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#152
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#119
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#83/#125/#112

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#86/#109
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#97
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#116
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#87/#111
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#145
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#148
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#79
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#154-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#78
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#136
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#117
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#115
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#85
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#120
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#110
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#81
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#151
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#135
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#82
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#144
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#147/#149
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#77-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#143/#139
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#124
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#108
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#107/#123
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#140
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#188-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#134
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#106
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#133
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#142
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#118
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#131
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#184
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#165

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#146
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#161
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#122
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#168
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#114
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#153
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#132
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#179
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#141
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#176
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#105
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#137
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#127
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#186
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#130/#164
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#178
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#138
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#163/#160
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#129/#158
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#182/#175
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#187
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#183
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#166
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#159
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#126-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#185
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#162
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#174
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#128
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#167
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#202-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#181
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#177
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#204/#200-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#171
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#173

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#172
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#192
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#156
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#157
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#180
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#193
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#197
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#191
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#199
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#198
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#201
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#170
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#190
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#196
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#203
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#169-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#208-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#207
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#189-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#195
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#194
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#205-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#206-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl10-BZ#209-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Monochlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Dichlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Trichlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Tetrachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Pentachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Hexachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Heptachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Octachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Nonachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Decachlorobiphenyl
GC/MS-SIM	EPA 8270D-SIM Isotope Dilution	1,4-Dioxane
GC/MS-SIM	EPA 522	1,4-Dioxane

Non-Potable Water		
Technology	**Method**	**Analyte**
SPE/LC/MS/MS	EPA 537	N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)
SPE/LC/MS/MS	EPA 537	N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)
SPE/LC/MS/MS	EPA 537	Perfluorobutanesulfonic acid (PFBS)
SPE/LC/MS/MS	EPA 537	Perfluorodecanoic acid (PFDA)
SPE/LC/MS/MS	EPA 537	Perfluorododecanoic acid (PFDoA)
SPE/LC/MS/MS	EPA 537	Perfluoroheptanoic acid (PFHpA)
SPE/LC/MS/MS	EPA 537	Perfluorohexanesulfonic acid (PFHxS)
SPE/LC/MS/MS	EPA 537	Perfluorohexanoic acid (PFHxA)
SPE/LC/MS/MS	EPA 537	Perfluorononanoic acid (PFNA)
SPE/LC/MS/MS	EPA 537	Perfluorooctanesulfonic acid (PFOS)
SPE/LC/MS/MS	EPA 537	Perfluorooctanoic acid (PFOA)
SPE/LC/MS/MS	EPA 537	Perfluorotetradecanoic acid (PFTA)
SPE/LC/MS/MS	EPA 537	Perfluorotridecanoic acid (PFTrDA)
SPE/LC/MS/MS	EPA 537	Perfluoroundecanoic acid (PFUnA)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	N-ethyl perfluorooctanesulfonamidoacetic acid N-EtFOSAA (cas# 2991-50-6)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	N-methyl perfluorooctanesulfonamidoacetic acid N-MeFOSAA (cas# 2355-31-9)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorobutanesulfonic acid (PFBS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorodecanoic acid PFDA (cas# 335-76-2)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorododecanoic acid PFDoA (cas# 307-55-1)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoroheptanoic acid PFHpA (cas# 375-85-9)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorohexanesulfonic acid (PFHxS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorohexanoic acid PFHxA (cas# 307-24-4)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorononanoic acid PFNA (cas# 375-95-1)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorooctanesulfonic acid (PFOS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorooctanoic acid PFOA (cas# 335-67-1)

Non-Potable Water		
Technology	**Method**	**Analyte**
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorotridecanoic acid PFTrDA (cas# 72629-94-8)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoroundecanoic acid PFUnA (cas# 2058-94-8)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-n-tetradecanoic acid PFTeDA (cas# 376-06-7)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-n-pentanoic acid (PFPeA)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-n-butanoic acid PFBA (cas# 375-22-4)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-1-decanesulfonate (PFDS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-1-nonanesulfonate (PFNS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-1-heptanesulfonate (PFHpS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluorohexanesulfonate (PFHxS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-1-pentanesulfonate (PFPeS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-1-butanesulfonate (PFBS)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	Perfluoro-1-octanesulfonamide (FOSA)
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	1H,1H,2H,2H-perfluorodecane sulfonate (8:2) 8:2FTS
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	1H,1H,2H,2H-perfluorooctane sulfonate (6:2) 6:2FTS
SPE/LC/MS/MS	EPA 537 (Mod) Isotope Dilution	1H,1H,2H,2H-perfluorohexane sulfonate (4:2) 4:2FTS
Preparation	**Method**	**Type**
Extraction	EPA 3510C	Separatory Funnel
Cleanup	EPA 3630C	Silica Gel Cleanup
Cleanup	EPA 3660B	Sulfur Removal Cleanup
Cleanup	EPA 3665A	Sulfuric Acid Cleanup
Cleanup	EPA 3610 / EPA 3611	Alumina Column Cleanup

Drinking Water		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM Isotope Dilution	1,4-Dioxane
GC/MS-SIM	EPA 522	1,4-Dioxane
SPE/LC/MS/MS	EPA 537	N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)
SPE/LC/MS/MS	EPA 537	N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)
SPE/LC/MS/MS	EPA 537	Perfluorobutanesulfonic acid (PFBS)
SPE/LC/MS/MS	EPA 537	Perfluorodecanoic acid (PFDA)
SPE/LC/MS/MS	EPA 537	Perfluorododecanoic acid (PFDoA)
SPE/LC/MS/MS	EPA 537	Perfluoroheptanoic acid (PFHpA)
SPE/LC/MS/MS	EPA 537	Perfluorohexanesulfonic acid (PFHxS)
SPE/LC/MS/MS	EPA 537	Perfluorohexanoic acid (PFHxA)
SPE/LC/MS/MS	EPA 537	Perfluorononanoic acid (PFNA)
SPE/LC/MS/MS	EPA 537	Perfluorooctanesulfonic acid (PFOS)
SPE/LC/MS/MS	EPA 537	Perfluorooctanoic acid (PFOA)
SPE/LC/MS/MS	EPA 537	Perfluorotetradecanoic acid (PFTA)
SPE/LC/MS/MS	EPA 537	Perfluorotridecanoic acid (PFTrDA)
SPE/LC/MS/MS	EPA 537	Perfluoroundecanoic acid (PFUnA)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#1-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#2
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#3-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#4/#10-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#9
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#7
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#6
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#5
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#8
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#19-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#14
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#30
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#18

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#11
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#17
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#12
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#27
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#13
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#24
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#16
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#32
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#15-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#34
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#23
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#54-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#29-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#50-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#26
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#25
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#53
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#-31
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#28
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#33
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#21/#20
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#51
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#45
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#22
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#73/#46
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#69
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#43
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#36
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#52
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#48
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#49
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#104-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#47
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#65/#75/#62
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#39
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#38

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#44
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#59
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#42
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#71
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#35
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#41
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#72
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#96
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#103
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#68/#64
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#40
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#37-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#100
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#94
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#57
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#67/#58
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#102
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#61
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#98
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#76
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#93
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#63
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#121
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#95/#88
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#74
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#155-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#70
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#66
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#91
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#80
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#55
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#92
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#89/#84
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#101/#90
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#56
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#113

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#99
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#150
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#60
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#152
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#119
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#83/#125/#112
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#86/#109
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#97
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#116
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#87/#111
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#145
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#148
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#79
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#154-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#78
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#136
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#117
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#115
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#85
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#120
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#110
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#81
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#151
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#135
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#82
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#144
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#147/#149
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#77-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#143/#139
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#124
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#108
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#107/#123
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#140
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#188-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#134
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#106

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#133
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#142
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#118
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#131
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#184
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#165
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#146
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#161
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#122
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#168
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#114
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#153
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#132
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#179
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#141
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#176
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#105
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#137
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#127
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#186
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#130/#164
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#178
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#138
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#163/#160
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#129/#158
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#182/#175
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#187
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#183
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#166
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#159
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#126-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#185
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#162
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#174
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#128
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#167

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#202-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#181
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#177
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#204/#200-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#171
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#173
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#172
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#192
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#156
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#157
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#180
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#193
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#197
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#191
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#199
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#198
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#201
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#170
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#190
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#196
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#203
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#169-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#208-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#207
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#189-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#195
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#194
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#205-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#206-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl10-BZ#209-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Monochlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Dichlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Trichlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Tetrachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Pentachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Hexachlorobiphenyls

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Heptachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Octachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Nonachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Decachlorobiphenyl
Gravimetric	SM 2540G	Percent Total Solids
Preparation	**Method**	**Type**
Extraction	EPA 3570	Microscale Extraction (MSE)
Waste Dilution	EPA 3580A	Waste Dilution
Cleanup	EPA 3630C	Silica Gel Cleanup
Cleanup	EPA 3660B	Sulfur Removal Cleanup
Cleanup	EPA 3665A	Sulfuric Acid Cleanup
Cleanup	EPA 3610 / EPA 3611	Alumina Column Cleanup

Biological Tissue		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#1-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#2
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl1-BZ#3-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#4/#10-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#9
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#7
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#6
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#5
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#8
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#19-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#14
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#30
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#18
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#11
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#17
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#12
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#27
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#13
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#24
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#16

Biological Tissue		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#32
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl2-BZ#15-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#34
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#23
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#54-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#29-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#50-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#26
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#25
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#53
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#-31
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#28
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#33
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#21/#20
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#51
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#45
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#22
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#73/#46
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#69
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#43
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#36
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#52
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#48
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#49
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#104-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#47
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#65/#75/#62
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#39
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#38
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#44
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#59
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#42
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#71
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#35
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#41
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#72

Biological Tissue		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#96
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#103
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#68/#64
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#40
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl3-BZ#37-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#100
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#94
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#57
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#67/#58
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#102
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#61
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#98
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#76
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#93
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#63
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#121
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#95/#88
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#74
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#155-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#70
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#66
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#91
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#80
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#55
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#92
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#89/#84
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#101/#90
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#56
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#113
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#99
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#150
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#60
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#152
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#119
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#83/#125/#112
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#86/#109

Biological Tissue		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#97
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#116
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#87/#111
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#145
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#148
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#79
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#154-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#78
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#136
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#117
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#115
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#85
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#120
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#110
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#81
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#151
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#135
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#82
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#144
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#147/#149
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl4-BZ#77-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#143/#139
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#124
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#108
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#107/#123
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#140
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#188-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#134
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#106
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#133
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#142
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#118
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#131
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#184
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#165
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#146

Biological Tissue		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#161
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#122
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#168
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#114
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#153
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#132
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#179
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#141
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#176
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#105
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#137
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#127
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#186
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#130/#164
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#178
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#138
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#163/#160
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#129/#158
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#182/#175
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#187
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#183
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#166
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#159
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl5-BZ#126-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#185
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#162
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#174
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#128
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#167
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#202-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#181
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#177
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#204/#200-Cal
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#171
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#173
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#172

Biological Tissue		
Technology	**Method**	**Analyte**
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#192
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#156
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#157
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#180
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#193
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#197
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#191
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#199
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#198
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#201
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#170
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#190
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#196
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#203
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl6-BZ#169-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#208-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#207
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl7-BZ#189-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#195
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#194
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl8-BZ#205-RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl9-BZ#206-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Cl10-BZ#209-Cal/RTW
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Monochlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Dichlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Trichlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Tetrachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Pentachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Hexachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Heptachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Octachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Nonachlorobiphenyls
GC/MS-SIM	EPA 8270D-SIM / EPA 680	Decachlorobiphenyl
Preparation	**Method**	**Type**
Extraction	EPA 3570	Microscale Extraction (MSE)
Extraction	Alpha SOP ID 2264	Tissue Extraction
Waste Dilution	EPA 3580A	Waste Dilution

Biological Tissue		
Technology	**Method**	**Analyte**
Cleanup	EPA 3630C	Silica Gel Cleanup
Cleanup	EPA 3660B	Sulfur Removal Cleanup
Cleanup	EPA 3665A	Sulfuric Acid Cleanup
Cleanup	EPA 3610 / EPA 3611	Alumina Column Cleanup

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-15	1,1,1,2-tetrachloroethane
GC/MS	EPA TO-15	1,1,1-trichloroethane
GC/MS	EPA TO-15	1,1,2,2-tetrachloroethane
GC/MS	EPA TO-15	1,1,2-trichloroethane
GC/MS	EPA TO-15	1,1-dichloroethane
GC/MS	EPA TO-15	1,1-dichloroethene
GC/MS	EPA TO-15	1,1-dichloropropene
GC/MS	EPA TO-15	1,2,3-trichlorobenzene
GC/MS	EPA TO-15	1,2,3-trichloropropane
GC/MS	EPA TO-15	1,2,4-trichlorobenzene
GC/MS	EPA TO-15	1,2,4-trimethylbenzene
GC/MS	EPA TO-15	1,2-dibromo-3-chloropropane
GC/MS	EPA TO-15	1,2-dibromoethane
GC/MS	EPA TO-15	1,2-dichlorobenzene
GC/MS	EPA TO-15	1,2-dichloroethane
GC/MS	EPA TO-15	1,2-dichloropropane
GC/MS	EPA TO-15	1,3,5-trimethylbenzene
GC/MS	EPA TO-15	1,3-butadiene
GC/MS	EPA TO-15	1,3-dichlorobenzene
GC/MS	EPA TO-15	1,3-dichloropropane
GC/MS	EPA TO-15	1,4-dichlorobenzene
GC/MS	EPA TO-15	1,4-dioxane
GC/MS	EPA TO-15	2,2,4-trimethylpentane
GC/MS	EPA TO-15	2,2-dichloropropane
GC/MS	EPA TO-15	2-butanone
GC/MS	EPA TO-15	2-chlorotoluene
GC/MS	EPA TO-15	2-hexanone
GC/MS	EPA TO-15	3-chloropropene

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-15	4-chlorotoluene
GC/MS	EPA TO-15	4-ethyl toluene
GC/MS	EPA TO-15	4-methyl-2-pentanone (MIBK)
GC/MS	EPA TO-15	acetone
GC/MS	EPA TO-15	acetonitrile
GC/MS	EPA TO-15	acrolein
GC/MS	EPA TO-15	acrylonitrile
GC/MS	EPA TO-15	benzene
GC/MS	EPA TO-15	benzyl chloride
GC/MS	EPA TO-15	bromobenzene
GC/MS	EPA TO-15	bromodichloromethane
GC/MS	EPA TO-15	bromoform
GC/MS	EPA TO-15	bromomethane
GC/MS	EPA TO-15	carbon disulfide
GC/MS	EPA TO-15	carbon tetrachloride
GC/MS	EPA TO-15	chlorobenzene
GC/MS	EPA TO-15	chlorodifluoromethane
GC/MS	EPA TO-15	chloroethane
GC/MS	EPA TO-15	chloroform
GC/MS	EPA TO-15	chloromethane
GC/MS	EPA TO-15	cis-1,2-dichloroethene
GC/MS	EPA TO-15	cis-1,3-dichloropropene
GC/MS	EPA TO-15	cyclohexane
GC/MS	EPA TO-15	dibromochloromethane
GC/MS	EPA TO-15	dibromomethane
GC/MS	EPA TO-15	dichlorodifluoromethane
GC/MS	EPA TO-15	dichlorofluoromethane
GC/MS	EPA TO-15	diisopropyl ether
GC/MS	EPA TO-15	ethanol
GC/MS	EPA TO-15	ethyl acetate
GC/MS	EPA TO-15	ethyl ether
GC/MS	EPA TO-15	ethylbenzene
GC/MS	EPA TO-15	Freon 113
GC/MS	EPA TO-15	Freon-114
GC/MS	EPA TO-15	n-heptane
GC/MS	EPA TO-15	hexachlorobutadiene

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-15	hexane
GC/MS	EPA TO-15	isopropyl alcohol
GC/MS	EPA TO-15	isopropylbenzene
GC/MS	EPA TO-15	m+p-xylene
GC/MS	EPA TO-15	methanol
GC/MS	EPA TO-15	methylene chloride
GC/MS	EPA TO-15	methyl methacrylate
GC/MS	EPA TO-15	MTBE
GC/MS	EPA TO-15	naphthalene
GC/MS	EPA TO-15	n-butylbenzene
GC/MS	EPA TO-15	n-propylbenzene
GC/MS	EPA TO-15	octane
GC/MS	EPA TO-15	o-xylene
GC/MS	EPA TO-15	n-pentane
GC/MS	EPA TO-15	p-isopropyltoluene
GC/MS	EPA TO-15	propane
GC/MS	EPA TO-15	propylene
GC/MS	EPA TO-15	sec-butylbenzene
GC/MS	EPA TO-15	styrene
GC/MS	EPA TO-15	tert-amyl methyl ether
GC/MS	EPA TO-15	tert-butlybenzene
GC/MS	EPA TO-15	tert-butyl ethyl ether
GC/MS	EPA TO-15	tetrachloroethene
GC/MS	EPA TO-15	tetrahydrofuran
GC/MS	EPA TO-15	toluene
GC/MS	EPA TO-15	trans-1,2-dichloroethene
GC/MS	EPA TO-15	trans-1,3-dichloropropene
GC/MS	EPA TO-15	trichloroethene
GC/MS	EPA TO-15	trichlorofluoromethane
GC/MS	EPA TO-15	vinyl acetate
GC/MS	EPA TO-15	vinyl bromide
GC/MS	EPA TO-15	vinyl chloride
GC/MS	EPA TO-15	decane
GC/MS	EPA TO-15	undecane
GC/MS	EPA TO-15	butane
GC/MS	EPA TO-15	nonane

Air and Emissions		
Technology	**Method**	**Analyte**
GC/MS	EPA TO-15	tert butyl alcohol
GC/MS	EPA TO-15	dodecane
GC/MS	EPA TO-15	butyl acetate
GC/MS	EPA TO-15	3-methylthiophene
GC/MS	EPA TO-15	2-ethylthiophene
GC/MS	EPA TO-15	2-methylthiophene
GC/MS	EPA TO-15	thiophene
GC/MS	EPA TO-15	benzothiophene
GC/MS	EPA TO-15	1,2,3-trimethylbenzene
GC/MS	EPA TO-15	indene
GC/MS	EPA TO-15	1,2,4,5-tetramethylbenzene
GC/MS	EPA TO-15	indan
GC/MS	EPA TO-15	1-methylnaphthalene
GC/MS	EPA TO-15	2-methylnaphthalene
GC/MS	EPA TO-15	acetaldehyde

Note:

1. This scope is formatted as part of a single document including Certificate of Accreditation No. L2474

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Acton, MA

for technical competence in the field of

Geotechnical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 4th day of June 2018.

President and CEO
For the Accreditation Council
Certificate Number 2965.01
Valid to March 31, 2020

For the tests to which this accreditation applies, please refer to the laboratory's Geotechnical Scope of Accreditation.

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

GEOTESTING EXPRESS, INC.
125 Nagog Park
Acton, MA 01720
Joe Tomei Phone: 978 635 0424

Valid To: March 31, 2020 Certificate Number: 2965.01

GEOTECHNICAL

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests under the ASTM recommended practice D3740:

Test Method:	**Test Description:**
Soils:	
ASTM D421	Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constant
ASTM D422 (Withdrawn 2016)[1]	Particle Size Analysis of Soils
ASTM D7928	Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
ASTM D698	Moisture-Density Relations (Standard Proctor)
ASTM D854	Specific Gravity of Soils
ASTM D1140	Amount of Material in Soils Finer than No. 200 Sieve
ASTM D1557	Moisture-Density Relations (Modified Proctor)
ASTM D1883	CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D2166/D2166M	Unconfined Compressive Strength of Cohesive Soil
ASTM D2216	Water Content of Soil, Rock & Soil-Aggregate Mixtures
ASTM D2434-68 (2006)	Permeability of Granular Soils (Constant Head)
ASTM D2435/D2435M	One-Dimensional Consolidation Properties of Soils
ASTM D2487	Classification of Soils for Engineering Purposes
ASTM D2488	Description and Identification of Soils (Visual-Manual Procedure)
ASTM D2850	Undrained, Unconsolidated Strength in Triaxial Compression
ASTM D2974	Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM D3080/D3080M	Direct Shear Test of Soils Under Consolidated Drained Conditions
ASTM D4015	Modulus and Damping of Soils by Resonant-Column Method
ASTM D3999	Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus
ASTM D4186	One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading
ASTM D4253	Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	Liquid Limit, Plastic Limits & Plasticity Index of Soils

5202 Presidents Court, Suite 220 | Frederick, MD 21703-8515 | Phone: 301 644 3248 | Fax: 240 454 9449 | www.A2LA.org

Test Method:	**Test Description:**
ASTM D4373	Rapid Determination of Carbonate Content of Soils
ASTM D4546	One-Dimensional-Swell or Settlement Properties of Cohesive Soils
ASTM D4718	Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D4767	Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D4829	Expansion Index of Soils
ASTM D4972	pH of Soils
ASTM G51	Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
ASTM D5084	Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D5311	Load Controlled Cyclic Triaxial Strength of Soil
ASTM D6467	Torsional Ring Shear Test to Determine Drained Residual Shear Strength of Cohesive Soils
ASTM D7608	Standard Test Method for Torsional Ring Shear test to determine Drained Fully Softened Shear Strength and Nonlinear Strength Envelope of Cohesive Soils for Slope with No Preexisting Shear Surfaces
ASTM D6528	Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils
ASTM D6913	Particle-Size Distribution (Gradation) of Soil using Sieve Analysis
ASTM D6938[2]	In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D7181	Consolidated Drained Triaxial Compression Test for Soils
ASTM D7263	Laboratory Determination of Density (Unit Weight) of Soil Specimens
ASTM G57	Soil Resistivity Using the Wenner Four-Electrode Method
AASHTO T307	Determining the Resilient Modulus of Soils and Aggregate Materials
ISO/TS 17892-1	Determination of Water Content
ISO/TS 17892-3	Determination of Particle Density - Pycnometer Method
ISO/TS 17892-5	Incremental Loading Oedometer Test
ISO/TS 17892-7	Unconfined Compression Test on Fine-Grained Soil
ISO/TS 17892-9	Consolidated Triaxial Compression Tests on Water-Saturated Soil
ISO/TS 17892-11	Determination of Permeability by Constant and Falling Head
ISO/TS 17892-12	Determination of Atterberg Limits
Rock:	
ASTM D2845	Laboratory Determination of Pulse Velocities and Ultrasonic Elastic Constants of Rock
ASTM D2936	Direct Tensile Strength of Intact Rock Core Specimens
ASTM D3967	Splitting Tensile Strength of Intact Rock Core Specimens
ASTM D4543	Preparing Rock Core as Cylindrical Test Specimens and Verifying Conformance to Dimensional and Shape Tolerances
ASTM D4644	Slake Durability of Shales and Similar Weak Rocks
ASTM D5607	Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force
ASTM D5731	Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications
ASTM D5873	Determination of Rock Hardness by Rebound Hammer Method
ASTM D6032	Determining Rock Quality Designation (RQD) of Rock Core

Test Method:	**Test Description:**
ASTM D7012	Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperature
ASTM D7625	Laboratory Determination of Abrasiveness of Rock Using the CERCHAR Method
Handewith (2000)	Punch Penetration
ISRM Part 1	Water Content of Rock
ISRM Part 2	Porosity/Density
ISRM Part 3	Saturation/Buoyancy

[1] This laboratory's scope contains withdrawn or superseded methods. As a clarifier, this indicates that the applicable method itself has been withdrawn or is now considered "historical" and not that the laboratory's accreditation for the method has been withdrawn.

[2] This laboratory meets A2LA *R104 – General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these tests.

Joint IAF-ILAC-ISO Communiqué
on the
Management Systems Requirements of ISO/IEC 17025:2005,
General requirements for the competence of testing and calibration laboratories

A laboratory's fulfilment of the requirements of ISO/IEC 17025:2005 means the laboratory meets both the technical competence requirements and **management system requirements** that are necessary for it to consistently deliver technically valid test results and calibrations. The **management system requirements** in ISO/IEC 17025:2005 (Section 4) are written in language relevant to laboratory operations and meet the principles of ISO 9001:2008 **Quality Management Systems — Requirements** and are aligned with its pertinent requirements.

IAF Chair	ILAC Chair	ISO Secretary General

January 2009

DEPARTMENT OF THE ARMY
ENGINEER RESEARCH AND DEVELOPMENT CENTER, CORPS OF ENGINEERS
GEOTECHNICAL AND STRUCTURES LABORATORY
WATERWAYS EXPERIMENT STATION, 3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199

December 6, 2016

Reply to the Attention of:
Concrete and Materials Branch

Mr. Joe Tomei
GeoTesting Express, Inc.
125 Nagog Park
Acton, MA 01720

Dear Mr. Tomei:

An inspection of your materials testing laboratory was performed on July 21, 2016. You provided deficiency corrections to the Materials Testing Center (MTC) on September 14, 2016. These deficiency corrections were compared to the ASTM Standards for compliance and found to be satisfactory. Your Quality System meets the requirements of the U.S. Army Corps of Engineers. The material test methods that you are validated to perform for the U.S. Army Corps of Engineers are:

Aggregate Tests: ASTM C40, C117, C127, C128, C136, C29, C88, C123, C131, C142, C535, C566, C702, C1077, C1252, D75, D2419, D4791, D5821, and CRD-C119.

Concrete Tests: ASTM C31, C39, C138, C143, C172, C173, C231, C1064, C470, C511, C617, C1077, and C1231.

Masonry, Mortar, & Grout Tests: ASTM C109, C140, C780, and C1019.

Rock Tests: ASTM D2845, D2936, D3740, D3967, D4543, D4644, D5240, D5312, D5313, D5607, D5731, D5873, D6032, D7012, D7625, CRD-C144, and CRD-C169.

Soil Tests: ASTM D421, D422, D558, D559, D560, D698, D854, D1140, D1556, D1557, D1883, D2166, D2168, D2216, D2434, D2435, D2487, D2488, D2850, D2974, D3080, D3740, D4220, D4253, D4254, D4318, D4546, D4643, D4767, D4829, D4972, D5084, D6913, D6938, D7181, D7263, and E329.

Geosynthetic Tests: ASTM C165, C203, C303, D374, D413, D751, D792, D1004, D1204, D1238, D1505, D1593, D1603, D1777, D3015, D3776, D3786, D3787, D4218, D4491, D4533, D4595, D4632, D4716, D4751, D4833, D4884, D4885, D5199, D5261, D5321, D5596, D5884, D5887, D5890, D5891, D5993, D5994, D6214, D6241, D6243, D6364, D6392, D6496, D6636, D6637, D6693, D6766, D6768, D7003, D7004, D7005, D7179, D7408, D7466, D7737, D7747, D7749, and FTM STD. No. 101c (method 2065).

We will add your laboratory to the list of commercial laboratories qualified to conduct material tests for the U.S. Army Corps of Engineers; see the MTC page at www.erdc.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/9254/Article/476661/materials-testing-center.aspx. All Corps offices will be notified of this decision and will have the opportunity to use your services. GeoTesting Express, Inc. Acton, MA will remain on our list of laboratories qualified to conduct material tests until **July 21, 2019** three (3) years from the date of the inspection.

Sincerely,

Alfred B. Crawley, PE
Director
Materials Testing Center

Copy Furnished: Mr. Silas T. Sanderson, New England District

ATTACHMENT D
Meeting Minutes, Devens PFAS Remedial Investigtion (RI) Area 1 Field Sampling Plan (FSP) Conference Call, 24 May 2018

Meeting Minutes
Devens PFAS Remedial Investigation (RI) Area 1 Field Sampling Plan (FSP)
Conference Call, 24 May 2018, 9:00 AM – 11:00 PM

Attendees (via Zoom Meeting platform):

Bob Simeone (Army BRAC)
Penny Reddy (USACE)
Mike Kulbersh (USACE)
Dan Groher (USACE)
Carol Keating (EPA)
Laurie O'Connor (EPA)
Dave Chaffin (MassDEP)
Mark Wetzel (Town of Ayer)
Greg Kemp (Mabbett)
Rich Doherty (PACE)
Mark Applebee (KGS)
Katie Thomas (KGS)
Jim Ropp (KGS)
Spence Smith (Jacobs)
Mark Hilyard (Jacobs)

Attachments

Area 1 FSP Meeting Materials
Area 1 FSP Figures (revised)
MassDEP e-mail 5/23/18 (with responses)

A conference call was held for the stakeholders to review the proposed sampling locations, rationale, and sampling plan for the Area 1 Areas of Contamination (AOCs) and the Grove Pond wellfield area of investigation. An overview of the RI sampling approach and design, including supporting location maps and summary tables, were provided to team members via e-mail on 15 May 2018 (see attachments).

Katie Thomas opened the meeting and provided an overview on the goals of the meeting and led a discussion to address comments received by MassDEP via email on 23 May 2018. Resolution to MassDEP comments are summarized in the attached e-mail.

Mark Hilyard then provided a summary of the general RI sampling approach. Results will be received and reviewed in a timely manner so that the data can be incorporated into the CSM for each AOC and help guide additional investigation. The groundwater vertical profiling and soil sampling results will be reviewed to determine if data gaps regarding extent of PFAS contamination in groundwater and soil remain and additional vertical profiling and soil sampling is needed. In addition, the vertical profiling and soil sampling results will be reviewed to determine the location and screen settings for permanent monitoring wells.

The discussion then focused on sampling locations and rationale for each AOC/area of investigation. The Grove Pond Wellfield investigation area was discussed first.

Grove Pond Wellfield Investigation (Figure 7)

Mark Hilyard described the rational for the sampling locations. The groundwater vertical profiling would be conducted first, followed by soil borings, followed by any surface water and sediment samples, if determined to be appropriate based on the data results. Groundwater and soil samples will be collected by direct push technology (DPT). Groundwater profiling will be conducted from the water table to refusal.

Carol Keating stated that permanent monitoring wells would also be needed in addition to the DPT sampling.

- It was discussed that permanent wells would be considered based upon the results of the DPT sampling.

Carol Keating stated that the groundwater vertical profiling locations on the north side of Grove Pond are not within the scope of the CERCLA RI, since they are located beyond the boundary of Devens and would not be characterizing groundwater originating from the installation. Carol Keating stated that she did not want the proposed sampling north of the pond to be at the expense of sampling that could be performed on Fort Devens property.

- It was discussed that characterization of groundwater from the north of the Grove Pond wellfield for PFAS is needed during the RI to adequately identify where the PFAS groundwater contamination is entering the Grove Pond wellfield from all directions.

- It is possible that sources other than Devens may also be contributing to the PFAS detected in the Ayer Municipal Wells.

Carol Keating stated that the depth to bedrock needs to be confirmed at the proposed vertical profiling locations, as this will be critical for EPA to make decisions about the success of the PFAS delineation during the RI, particularly in Area 1.

- It was discussed that the need to confirm bedrock at every groundwater vertical profile location may not be necessary. The groundwater vertical profiling results at each boring will be reviewed to determine if the bottom of PFAS groundwater contamination has been adequately delineated. If several intervals of clean water were observed between the bottom of PFAS groundwater contamination and bedrock, it may not be necessary to confirm bedrock at that location.

- It was also discussed that, if needed, the top of bedrock may be determined in conjunction with the soil coring conducted along with field lithologic descriptions, during advancement of select borings advanced in support of permanent groundwater monitoring well installation.

Carol Keating indicated that two historic wells in the vicinity of Grove Pond (PW-1 and PW-2 from the Gannett Fleming Report) may have been installed to bedrock, which could provide top-of-bedrock elevation information.

- The Army team agreed to review historic reports for boring and/or well construction logs for these two historic wells.

- It was discussed that they may be numerous historic monitoring wells that are present in the area of the Grove Pond Municipal Wellfield. These historic wells could potentially be used to augment the groundwater vertical profiling data and subsequent monitoring well network that is installed. The Army team agreed to review any available historic reports in an effort to determine if such monitoring wells are present and find well

construction information. However, it was noted that many of these old observation wells may not be in good condition. Also, observation wells located close to the extraction wellfield may not provide much new information about the overall PFAS extent or site hydrogeology.

- Carol Keating recommended that the Army check for inconsistencies in the old investigation reports (e.g., Gannett Fleming report and the 2012 MNG well study).

Carol Keating and Laurie O'Connor indicated that the proposed groundwater vertical profiles located to the south of the Grove Pond wellfield were spaced too far apart to adequately characterize PFAS in the aquifer in this area and to identify a potential source that may be located upgradient. Carol Keating requested additional sample locations be included in order to address potential data gaps.

- The Army team agreed to reevaluate the spacing of groundwater vertical profiles located to the south of the Grove Pond wellfield.

- It was discussed that the Army, EPA, and MassDEP would hold working technical meetings during the RI field effort in order to evaluate the data as it became available in order to help guide decisions about subsequent sampling locations.

Carol Keating questioned whether the subsequent transect that is planned to the south and upgradient of the initial Grove Pond vertical profile is too far upgradient, particularly if PFAS are detected at the water table at existing monitoring wells CSMS-11-01 and MNG-3.

- It was discussed how the location of this transect is tentatively proposed to reflect a reasonable approximation of where shallower PFAS groundwater contamination may be present upgradient of CSMS-11-01 and MNG-3, given the depth interval of PFAS detected at these monitoring wells.

- The Army team agreed to shift the location of the transect slightly to the north.

AOC 74 (Figure 2)

Mark Hilyard described the rational for the sampling locations (groundwater vertical profiles and soil borings).

Carol Keating recommended that some of the proposed soil boring locations be converted to groundwater profiles. Laurie O'Connor stated that more groundwater profiles were needed on the downgradient side by location 74VP-2. Carol Keating stated that there should be deeper sampling (to bedrock) as well as on the other side of the brook.

- It was discussed that the proposed locations were a first approach to the site, and that more sampling locations could be added, if appropriate based on the initial round of results.

- The Army team agreed to add two more groundwater profiles (74VP-9 and -10) next to 74VP-2 to provide for a transect along the brook.

AOC 57 Area-1 (Figure 4)

See MassDEP comment and response in attached e-mail. The Army team explained that the goal for the two soil and groundwater vertical profiling locations proposed at AOC 57 Area 1 was determine absence or presence of PFAS. If PFAS contamination is detected in groundwater and/or soil, then additional borings would be advanced.

Laurie O'Connor requested that the storm water outfall locations be indicated on all the AOC 57 figures.

AOC 57 Area-2 (Figure 5)

Carol Keating and Laurie O'Connor requested that groundwater vertical profiling be conducted at the proposed soil boring located south and downgradient of groundwater vertical profiling location 57VP2-2.

- The Army team agreed that groundwater vertical profiling will be added to this soil boring location.

Carol Keating and Laurie O'Connor requested that a full round of groundwater data be collected at existing wells at AOC 57 as part of the RI. Kathie Thomas indicated that existing wells at AOC 57 would be sampled as part of the RI.

AOC 57 Area-3 (Figure 6)

Carol Keating and Laurie O'Connor requested that groundwater vertical profiling be conducted at the proposed soil boring located south and downgradient of groundwater vertical profiling location 57VP3-2.

- The Army team agreed that groundwater vertical profiling will be added to this soil boring location.

AOC 75 (Figure 3)

Carol Keating and Laurie O'Connor requested that groundwater vertical profiling and soil sampling be conducted at a boring located to the northeast of the former building footprint.

- The Army team agreed to install an additional groundwater vertical profiling and soil boring

EPA also requested that an additional groundwater vertical profile be advanced to the northeast downgradient vertical profile 75-VP-2, because there may be more of a northern component of flow to groundwater in this area.

- The Army team agreed to install an additional groundwater vertical profiling boring at this location.

Mike Kulbersh requested that a yellow transect line through locations 75-VP-5, 75-VP-6 and 75-VP-7 be added to this figure.

- KGS agreed to add the transect line to the figure.

Laurie O'Connor indicated that the ground surface near the proposed soil boring location near former direct push location SA75-17-01 is too hummocky or full of debris to facilitate rig access. Penny Reddy agreed, based on her recollection of surface conditions observed during a site walk.

- The Army team agreed to adjust location of this soil boring to the edge of the hummocky and debris area at AOC 75 in order to facilitate access with direct push rig.

Surface Water Sampling Locations (Figure 8):

Per MassDEP comment received via e-mail on 23 May 2018, the team clarified the location of discharge of Ayer Municipal well #8. According to Mark Wetzel, the effluent from Well #8 is being discharged to the shoreline between Ayer municipal wells #7 and #8.

The Army team agreed to adjust the location of Grove Pond surface water/sediment sample location, GPSW-2 to the east, away from the discharge point.

The Army team also discussed the need for additional sediment/surface water sampling in Cold Spring Brook at AOCs 57 and 74, due to uncertainty regarding the direction of groundwater flow at AOC 74 and extent of PFAS plume adjacent to the brook at each AOC.

The Army team will evaluate the need for additional surface water/sediment sample locations or waiting until groundwater is characterized before finalizing the SW/SED locations.

The meeting adjourned at 11:40 AM. The Army team plans to send EPA and MassDEP a draft RI Work Plan, with QAPP and Area 1 Field Sampling Plan addenda, by July 10 or sooner.

ATTACHMENTS

DEVENS PFAS REMEDIAL INVESTIGATION

Area 1 Field Sampling Planning Meeting

24 May 2018

Groundwater

- Groundwater vertical profiling will be completed at Area 1 using direct push technology to define the vertical and lateral extent of PFAS contamination in groundwater at and near the Grove Pond municipal wellfield, and AOCs 57, 74, and 75 at Devens. The extent of vertical profiling activities within each area of investigation is provided on Figure 1 and is intended to assist reviewers in visualization of all the activities in Area 1.
- Proposed vertical profiling locations at each AOC and the Grove Pond municipal wellfield are shown on Figures 2 to 7.
    - The yellow "Groundwater Vertical Profiling Transects" shown on figures 2 to 6 are provided to aid reviewers in assessing relative positions of vertical profiling locations with respect to approximate groundwater flow direction and other vertical profiling locations.
    - The "Subsequent Groundwater Vertical Profiling Transects" shown on Figure 7 will be used to approximate areas for subsequent groundwater vertical profiling locations that will likely be needed to track PFAS impacts at the Grove Pond wellfield back to a potential source(s) at Devens.
- The rationale and sampling plan for each groundwater vertical profile location proposed for Area 1 is provided in Table 1.
- The groundwater vertical profiling samples will be collected at 10-foot intervals from the water table to refusal or bedrock. The samples will be analyzed for PFAS via Method 537.
- At AOCs 57, 74 and 75, the groundwater vertical profile borings are generally located within, downgradient, upgradient and cross gradient to areas of known PFAS groundwater contamination (Figure 2 to 6).
- The initial set of 8 groundwater vertical profile borings at the Grove Pond municipal wellfield are located on a perimeter around the wellfield to characterize PFAS in groundwater that may be entering the wellfield from all directions (Figure 7).
    - No step-outs are planned for off-base vertical profiles that have PFAS.
    - Additional transects of vertical profiling locations will likely be needed at Devens upgradient of the Grove Pond wellfield. Vertical profile locations may step out to define the width of the plume or perpendicular to groundwater flow to delineate plume length, delineate the core, and find a potential source(s). The general location of transects upgradient of the Grove Pond wellfield are shown on Figure 7. Subsequent vertical collection intervals may be revised based on initial results.

- The groundwater vertical profiling PFAS data set will be augmented with sampling for PFAS at existing monitoring wells, if present. The samples will be analyzed for PFAS via Method 537. The locations of existing groundwater monitoring wells are shown on Figures 4 through 7. Well construction information for existing monitoring wells to be sampled for PFAS at each area (if present) is provided in Table 2.
- Additional groundwater vertical profiling locations may be necessary. The PFAS results from the groundwater vertical profiles and existing monitoring wells will be reviewed to determine if data gaps regarding the extent of PFAS contamination in groundwater remain. The collection intervals for additional groundwater vertical profiling locations may be revised based on initial results.

Soil

- Soil borings will be advanced at AOCs 57, 74, and 75 using direct push technology to collect soil samples to determine the nature and extent of soil contamination, to assess the potential of an ongoing source, and to provide data for the completion of human health and ecological risk assessments. At AOC 74 seven soil borings, at AOC 75 six soil borings, at AOC 57 Area 1 two soil borings, at AOC 57 Area 2 six soil borings, and at AOC 57 Area 3 four soil borings are planned.
- The locations of soil borings are shown on Figures 2 through 6. In general, borings will be advanced within, upgradient, downgradient, and cross gradient of areas of PFAS soil and/or groundwater contamination identified in the SI (Weston, 2018) and the LTM groundwater sampling event (KGS, 2018). Some of the soil borings are collocated with vertical profiling locations.
- Vadose zone soil samples will be collected from the following depth intervals and submitted for PFAS analysis via Method 537:

  0 - 0.5 ft
  0.5 - 3 ft
  3 - 7 ft
  7 - 15 ft
  Within 2 feet of the water table

- The PFAS results from the 0 - 0.5 ft and the 0.5-3 ft samples will be used to support the ecological risk evaluation. The PFAS results from 0-15 ft intervals will be used to provide data to evaluate risks to human health through a residential exposure scenario to accessible soils (0-3 ft) and construction worker exposure scenario to potentially accessible soils (3-15 ft). Soil samples will be collected within two-feet of the water table (if the water table is deeper than the intervals specified above) and submitted for PFAS analysis to provide additional data for evaluating a potential leaching threat to groundwater.
- Final depth of soil sampling intervals will end at the water table at locations where water table is less than 15 feet.
- PFAS soil data will be reviewed to identify soil samples with highest PFAS concentrations. Soil samples with the highest reported PFAS concentrations will be submitted for total oxidizable precursor assay (TOPA) and total organic carbon (TOC) analysis.

- The need for soil sampling near the Grove Pond municipal wellfield is not anticipated at this time. PFAS groundwater contamination in this investigation area is likely distal from the source and likely exists only in dissolved phase.
- If a source soil area (other than AOCs 74, 75 or 57) is identified within Area 1, additional soil borings may be conducted.
- It is anticipated that the planned soils borings at each AOC will encompass the lateral extent of soil contamination. If not, additional soil borings may be necessary. The number and location of subsequent soil borings will be determined based on review of initial soil boring results, initial vertical profiling results, and results of samples collected from existing monitoring wells.

Surface Water and Sediment

- Surface water and sediment samples will be collected from six locations along Cold Spring Brook (Figure 8). The samples will be analyzed for PFAS via Method 537, TOC, and grain size.
    - This initial transect has been designed to assess if there is potential for an ecological or human health risk from exposure to PFAS that may be present in sediments and surface water at Cold Spring Brook.
    - If PFAS concentrations in surface water and/or sediment exceed the site-specific screening levels, additional samples may be needed to identify the AOC contributing the greatest risk. The additional sample locations will be based on initial PFAS results.
- Surface water and sediment samples will be collected from five locations within Grove Pond and from one location at Balch Pond. The samples will be analyzed for PFAS via Method 537, TOC, and grain size.

Installation of New Monitoring Wells

- Approximately 30 new monitoring wells are anticipated be installed at Area 1. At AOC 74 an estimated six wells, at AOC 75 an estimated six wells, at AOC 57 Area 1 an estimated five wells, at AOC 57 Area 2 an estimated five wells, and upgradient of the Grove Pond wellfield and estimated 8 wells would be installed.
- The locations and screen settings of the new groundwater monitoring wells will be based on a review of the PFAS data obtained from groundwater vertical profiling, soil sampling and existing monitoring wells.
- The monitoring well network will be designed to monitor areas of PFAS groundwater contamination delineated within Area 1 as well as provide bounding locations to demonstrate the limits of PFAS contamination in groundwater.
- Monitoring well couplets will be installed adjacent to Cold Spring Brook at AOCs 74 and 57 (areas 2 and 3) to evaluate the potential for vertical gradients on the northwestern side of Cold Spring brook.

- During well installation at select borings, soil core samples will be collected in the saturated zone for field lithologic classification. Select samples from the core will be submitted for TOC and grain size analysis.
- After new monitoring wells are installed, a synoptic water level measurement event will be conducted for Area 1 to evaluate groundwater flow within and between each area of investigation.
- Groundwater samples will be collected from the new monitoring wells and analyzed for PFAS via Method 537. Select wells screened within the plume(s) will be sampled for dissolved organic carbon and TOPA.

Table 1
Groundwater Vertical Profiling Rationale
Area 1 Field Sampling Plan
Devens PFAS RI Workplan

Proposed Location	Rationale	Path Forward If PFAS is Detected in Groundwater[(1)]
Grove Pond Municipal Well Field		
GPVP-1	Determine if PFAS is present in groundwater to the northwest of Grove Pond Wellfield.	• No additional profiling needed. • Inform stakeholders of PFAS contamination at this location.
GPVP-2	Determine if PFAS is present in groundwater to the north of Grove Pond Wellfield.	• No additional profiling needed. • Inform stakeholders of PFAS contamination at this location.
GPVP-3	Determine if PFAS is present in groundwater to the northeast of Grove Pond Wellfield.	• No additional profiling needed. • Inform stakeholders of PFAS contamination at this location.
GPVP-4	Determine if PFAS is present in groundwater to the east of Grove Pond Wellfield.	• No additional profiling needed. • Inform stakeholders of PFAS contamination at this location.
GPVP-5	Determine if PFAS is present in groundwater to the east of Grove Pond Wellfield.	• Evaluate flow direction for additional vertical profile borings located upgradient or cross gradient.
GPVP-6	Characterize vertical extent of PFAS contamination in an area of known groundwater contamination to the south of Grove Pond Wellfield.	• Establish a vertical profile location further upgradient, to the south of GPVP-6. Distance is anticipated to be along a transect that passes through MNG-2 through MNG-7.
GPVP-7	Characterize vertical extent of PFAS contamination in an area of known groundwater contamination to the south of Grove Pond Wellfield.	• Establish a vertical profile location further upgradient, to the south of GPVP-7. Distance is anticipated to be along a transect that passes through MNG-2 through MNG-7.
GPVP-8	Determine if PFAS is present in groundwater to the west of Grove Pond Wellfield.	• Establish a vertical profile location further upgradient, to the south and west of GPVP-8. Distance is anticipated to be along a transect that passes through MNG-2 through MNG-7.
Area of Concern 74		
74VP-1	Characterize vertical extent of PFAS contamination in groundwater in area of known PFAS contamination.	• Evaluate data from surrounding locations.
74VP-2	Characterize vertical extent of PFAS contamination in groundwater in aquifer downgradient of known PFAS contamination and adjacent to Cold Spring Brook.	• Evaluate data from surrounding locations. • Evaluate potential for underflow of Cold Spring Brook, by reviewing elevation of observed PFAS in groundwater and measuring vertical hydraulic gradients with installation of nested piezometers or monitoring wells at this location.
74VP-3	Bound extent of PFAS contamination in groundwater to the southwest.	• Evaluate need for a vertical profile location cross gradient further to the southwest based on a review of magnitude and depth of detections at this profile.
74VP-4	Bound extent of PFAS contamination in groundwater to the northeast.	• Evaluate need for a vertical profile location cross gradient further to the northeast based on a review of magnitude and depth of detections at this profile.
74VP-5	Determine if PFAS contamination is present in groundwater to the east of Bldg. 3773 at AOC 74.	• Evaluate need for a vertical profile location cross gradient further to the northeast based on a review of magnitude and depth of detections at this profile.

Table 1
Groundwater Vertical Profiling Rationale
Area 1 Field Sampling Plan
Devens PFAS RI Workplan

Proposed Location	Rationale	Path Forward If PFAS is Detected in Groundwater[1]
74VP-6	Determine if PFAS contamination is present in groundwater to the north of Bldg. 3773 at AOC 74.	• Evaluate need for a vertical profile locations to the southwest based on a review of magnitude and depth of detections at this profile.
74VP-7	Determine if PFAS contamination is present in groundwater to the north of Bldg. 3773 at AOC 74.	• Evaluate need for a vertical profile locations to the north based on a review of magnitude and depth of detections at this profile.
74VP-8	Determine if PFAS contamination is present in groundwater to the north of Bldg. 3773 at AOC 74.	• Evaluate vertical profile data in conjunction with vertical profile results obtained from Grove Pond investigation area.
Area of Concern 75		
75VP-1	Determine if PFAS is present in groundwater upgradient of AOC-75.	• Evaluate need for a vertical profile that is further upgradient of location 75VP-1 based on a review of the magnitude and depth of detections at this profile.
75VP-2	Determine if PFAS is present in groundwater downgradient, to the northeast of known PFAS detections in groundwater at AOC-75.	• Evaluate need for a vertical profile location that is further cross gradient, to the north of 75VP-2 based on a review of the magnitude and depth of detections at this profile. • Evaluate need for a vertical profile location further downgradient, to the east of 75VP-2 based on a review of the magnitude and depth of detections at this profile.
75VP-3	Determine if PFAS is present in groundwater that is downgradient of known PFAS detections in AOC-75 groundwater.	• Evaluate need for a profile location that is further downgradient, to the east, of 75VP-3 based on a review of the magnitude and depth of detections at AOC-75 and AOC 57 Area 1 (located to the east and downgradient).
75VP-4	Determine if PFAS is present in groundwater downgradient, to the southeast of known PFAS detections at AOC-75.	• Evaluate need for a vertical profile location that is further cross gradient, to the south of 75VP-4 based on a review of the magnitude and depth of detections at this profile. • Evaluate need for a vertical profile location further downgradient, to the east of 75VP-4 based on a review of the magnitude and depth of detections at this profile.
75VP-5	Determine if PFAS is present in groundwater cross gradient, to the north of known PFAS detections at AOC-75.	• Evaluate need for a vertical profile location that is further cross gradient, to the north of 75VP-5 based on a review of the magnitude and depth of detections at this profile.
75VP-6	Characterize vertical extent of PFAS in an area of known groundwater contamination at AOC 75.	• Evaluate data from surrounding locations.
75VP-7	Determine if PFAS is present in groundwater cross gradient, to the south of known PFAS detections at AOC-75.	• Evaluate need for a vertical profile location that is further cross gradient, to the south of 75VP-7 based on a review of the magnitude and depth of detections at this profile.

Table 1
Groundwater Vertical Profiling Rationale
Area 1 Field Sampling Plan
Devens PFAS RI Workplan

Proposed Location	Rationale	Path Forward If PFAS is Detected in Groundwater[(1)]
Area of Concern 57, Area 1		
57VP-1-1	Determine if PFAS is present in groundwater at Area 1. Directly downgradient of storm drain outfall.	• Evaluate need for vertical profile location further upgradient, northwest of 57VP-1-1, based on a review of the magnitude and depth of the borings advanced at this area. • Evaluate need for vertical profile location further cross gradient, north and south of 57VP-1-1, based on a review of the magnitude and depth of the borings advanced at this area.
57VP-1-2	Determine if PFAS is present in groundwater at Area 1. Directly downgradient of storm drain outfall.	• Evaluate need for vertical profile location further downgradient, southeast of 57VP-1-2, based on a review of the magnitude and depth of the borings advanced at this area. • Evaluate need for vertical profile location further cross gradient, north and south of 57VP-1-2, based on a review of the magnitude and depth of the borings advanced at this area.
Area of Concern 57, Area 2		
57VP-2-1	Determine if PFAS is present in groundwater upgradient of Area 2.	• Evaluate need for a vertical profile location further upgradient, northwest of 57VP-2-1, based on a review of the magnitude and depth of detections at this profile. • Evaluate need for a vertical profile location further cross gradient, northeast and west of 57VP-2-1, based on a review of the magnitude and depth of detections at this profile.
57VP-2-2	Characterize vertical extent of PFAS in groundwater within area of known PFAS contamination in groundwater.	• Evaluate data from surrounding locations.
57VP-2-3	Determine if PFAS is present at Area 2 groundwater cross gradient to upgradient portion of Area 2.	• Evaluate need for a vertical profile location further upgradient and cross gradient, to the northwest of 57VP-2-3 based on a review of the magnitude and depth of detections at this profile.
57VP-2-4	Determine if PFAS is present at Area 2 groundwater cross gradient to upgradient portion of Area 2.	• Evaluate need for a vertical profile location further upgradient and cross gradient, to the northeast of 57VP-2-4 based on a review of the magnitude and depth of detections at this profile.
57VP-2-5	Determine if PFAS is present at Area 2 groundwater cross gradient to downgradient portion of Area 2, adjacent to Cold Spring Brook.	• Evaluate need for a vertical profile location cross gradient further to the west based on a review of magnitude and depth of detections at this profile. • Evaluate potential for underflow of Cold Spring Brook, by reviewing elevation of observed PFAS in groundwater at this location and considering vertical hydraulic gradients measured at nearby nested piezometers or monitoring wells at this AOC.
57VP-2-6	Characterize vertical extent of PFAS in groundwater within area of known PFAS contamination in groundwater, adjacent to Cold Spring Brook.	• Evaluate potential for underflow of Cold Spring brook, by reviewing elevation of observed PFAS and measuring vertical hydraulic gradients with installation of nested piezometers or monitoring wells at this location.
57VP-2-7	Determine if PFAS is present at Area 2 groundwater cross gradient to downgradient portion of Area 2, adjacent to Cold Spring Brook.	• Evaluate need for a vertical profile location cross gradient further to the northeast based on a review of magnitude and depth of detections at this profile. • Evaluate potential for underflow of Cold Spring Brook, by reviewing elevation of observed PFAS in groundwater at this location and considering vertical hydraulic gradients measured at nearby nested piezometers or monitoring wells at this AOC.

Table 1
Groundwater Vertical Profiling Rationale
Area 1 Field Sampling Plan
Devens PFAS RI Workplan

Proposed Location	Rationale	Path Forward If PFAS is Detected in Groundwater[1]
Area of Concern 57, Area 3		
57VP-3-1	Determine if PFAS is present in groundwater upgradient and cross gradient of known groundwater contamination at Area 3.	• Evaluate need for a vertical profile location further upgradient cross gradient, to the northwest of 57-3-1. Distance to be dependent on magnitude and depth of detections.
57VP-3-2	Determine if PFAS is present in groundwater upgradient of known groundwater contamination at Area 3.	• Evaluate need for a vertical profile location further upgradient, to the north of 57-3-2. Distance to be dependent on magnitude and depth of detections.
57VP-3-3	Determine if PFAS is present in groundwater upgradient and cross gradient of known groundwater contamination at Area 3.	• Evaluate need for a vertical profile location further upgradient and cross gradient, to the northeast of 57-3-3. Distance to be dependent on magnitude and depth of detections.
57VP-3-4	Characterize vertical extent of PFAS in groundwater at an area of known PFAS contamination in groundwater.	• Evaluate data from surrounding locations.
57VP-3-5	Determine if PFAS is present at Area 3 groundwater cross gradient to downgradient portion of Area 3, adjacent to Cold Spring Brook.	• Evaluate need for a vertical profile location cross gradient, southwest of 57VP-3-5, based on a review of magnitude and depth of detections at this profile. • Evaluate potential for underflow of Cold Spring Brook, by reviewing elevation of observed PFAS in groundwater at this location and considering vertical hydraulic gradients measured at nearby nested piezometers or monitoring wells at this AOC.
57VP-3-6	Characterize vertical extent of PFAS in groundwater at an area of known PFAS contamination in groundwater.	• Evaluate potential for underflow of Cold Spring brook, by reviewing elevation of observed PFAS and measuring vertical hydraulic gradients with installation of nested piezometers or monitoring wells at this location.
57VP-3-7	Determine if PFAS is present at Area 3 groundwater cross gradient to downgradient portion of Area 3, adjacent to Cold Spring Brook.	• Evaluate need for a vertical profile location cross gradient further to the northeast based on a review of magnitude and depth of detections at this profile. • Evaluate potential for underflow of Cold Spring Brook, by reviewing elevation of observed PFAS in groundwater at this location and considering vertical hydraulic gradients measured at nearby nested piezometers or monitoring wells at this AOC.

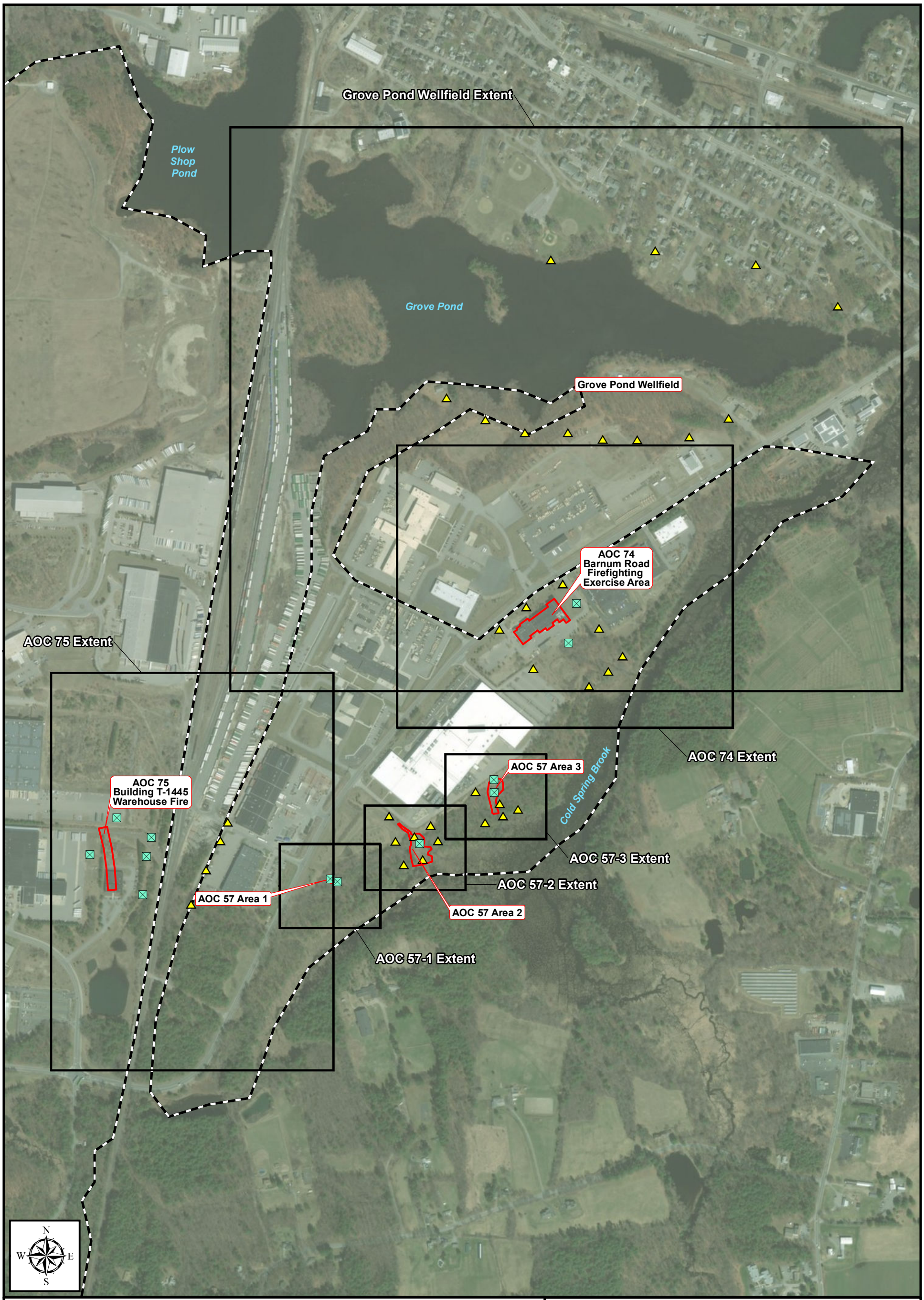
Notes:
AOC = Area of Concern
PFAS = per- and poly-fluoroalkyl substances

Notes:
1. Evaluation of need for additional vertical profiling locations will be based on a review of PFAS data from this, nearby vertical profiles, and existing monitoring wells to determine if data gaps regarding the extent of PFAS contamination in groundwater exist.

Table 2
Existing Monitoring Well Construction Information
Area 1 Field Sampling Plan
Devens PFAS RI Workplan

Monitoring Well	Screen Interval	Well Screen Intervals	Top of Casing Elevation	Ground Surface Elevation
	(ft NGVD)	(ft BTOC)	(ft NGVD)	(ft NGVD)
Grove Pond Well Field				
92-5	--	--	--	--
CSMS-11-01	214.3 - 224.3	30 - 40	224.29	251.27
CSMS-11-02	212.7 - 222.7	30 - 40	252.68	249.49
MNG-3	191.6 - 201.6	--	254.56	252.16
MNG-2*	--	--	238.81	236.11
MNG-5*	--	--	238.06	235.73
MNG-6*	--	--	254.87	250.8
MNG-7*	--	--	254.65	250.58
AOC-57 Area 2				
57M-03-01X	215.50 – 225.50	12.40 - 22.40	237.90	235.50
57M-03-02X	213.30 – 223.30	3.80 - 13.80	227.10	225.30
57M-03-03X	210.34 – 220.34	3.30 - 13.30	223.64	222.34
57M-03-04X	210.22 – 220.22	3.80 - 13.80	224.02	222.22
57M-03-05X	214.87 – 224.87	3.90 - 13.90	224.33	222.43
57M-03-06X	212.34 – 222.34	3.50 - 13.50	224.56	223.06
57M-95-05X	215.48 - 225.48	12.44 - 22.44	237.31	234.87
57M-95-06X	214.87 – 224.87	14.22 - 24.22	236.56	234.42
57M-95-07X	212.34 – 222.34	4.21 - 14.21	224.57	223.36
57WP-05-01	210.36 – 220.36	--	--	--
57WP-06-02	215.48 - 225.48	20.00 - 25.00	222.91	--
AOC-57 Area 3				
57M-95-03X	215.48 - 225.48	9.49 - 19.49	234.97	232.48
57M-96-10X	214.09 - 224.09	5.46 - 15.46	229.55	227.09
57M-96-11X	210.18 - 220.18	4.20 - 14.20	224.38	222.18
57M-96-12X	212.82 - 222.82	5.05 - 15.05	227.87	224.82
57M-96-13X	213.06 - 223.06	4.67 - 14.67	227.73	225.06
57P-98-03X	--	--	222.58	--
57P-98-04X	--	--	223.72	--
57WP-06-03	202.69 - 207.69	15.00 - 20.00	222.69	--

Key:
AOC = Area of Concern
bgs = below ground surface
BTOC = below top to casing
ft = feet
NGVD = National Geodetic Vertical Datum
PFAS = per- and polyfluoroalkyl substances
* = the well is damaged, well repair will be evaluated, and potentially conducted. If well repairs are conducted and are successful, the well will be sampled.
-- = Information is not available



Legend

- Proposed Soil Boring and Vertical Profiling Location
- Proposed Vertical Profiling Location
- Area of Contamination (AOC)
- Former Fort Devens Boundary

Area 1 Figure Extents
Devens PFAS RI - Area 1 FSP Addenda

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

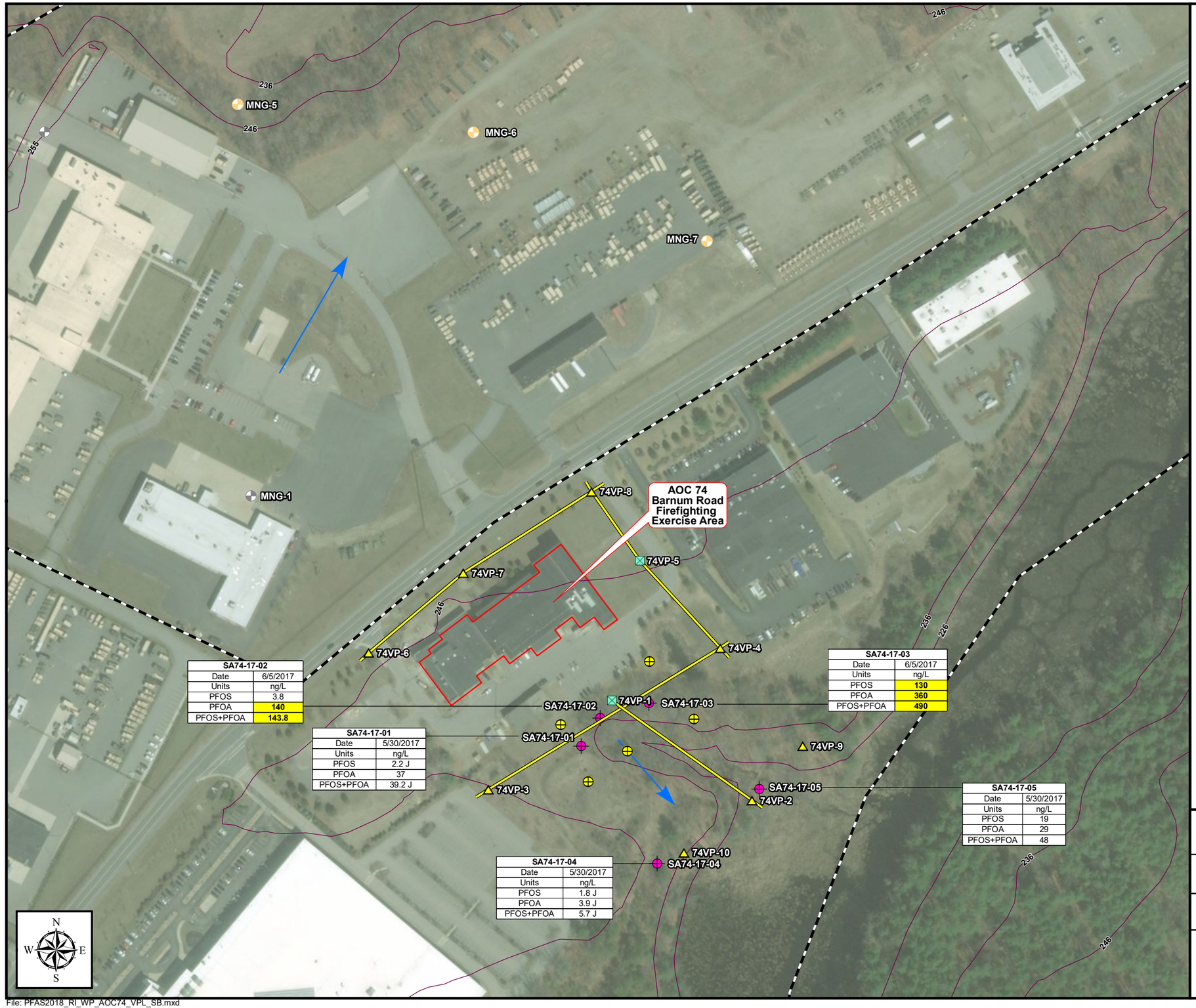
0 325 650
Feet

Date: 05/25/2018

Figure 1

File: PFAS2018_RI_WP_Area1_Extents_VPL.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



SA74-17-02	
Date	6/5/2017
Units	ng/L
PFOS	3.8
PFOA	**140**
PFOS+PFOA	**143.8**

SA74-17-03	
Date	6/5/2017
Units	ng/L
PFOS	**130**
PFOA	**360**
PFOS+PFOA	**490**

SA74-17-01	
Date	5/30/2017
Units	ng/L
PFOS	2.2 J
PFOA	37
PFOS+PFOA	39.2 J

SA74-17-05	
Date	5/30/2017
Units	ng/L
PFOS	19
PFOA	29
PFOS+PFOA	48

SA74-17-04	
Date	5/30/2017
Units	ng/L
PFOS	1.8 J
PFOA	3.9 J
PFOS+PFOA	5.7 J

Legend

- Proposed Soil Boring and Vertical Profiling Location
- Proposed Vertical Profiling Location
- Proposed Soil Boring Location
- Groundwater Vertical Profiling Transects
- Monitoring Well (Damaged)
- Monitoring Well (Destroyed)
- Temporary Well Location from SI
- Approximate Groundwater Flow Direction
- Topographic Contour (feet above sea level)
- Area of Contamination (AOC)
- Former Fort Devens Boundary

Note:
Topographic Contour Source: MassGIS, Elevation Contours (1:5,000) - North American Vertical Datum of 1988.

Bold/highlighted results exceed EPA LHA of 70 ng/L for separate or combined PFOS + PFOA.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

AOC 74 Proposed Vertical Profiling and Soil Boring Locations
Devens PFAS RI - Area 1 FSP Addenda

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 100 200
Feet

Date: 05/25/2018

Figure 2

File: PFAS2018_RI_WP_AOC74_VPL_SB.mxd

SA75-17-01	
Date	6/5/2017
Units	ng/L
PFOS	3.5 J
PFOA	2.3 J
PFOS+PFOA	5.8 J

SA75-17-02	
Date	6/5/2017
Units	ng/L
PFOS	49
PFOA	18
PFOS+PFOA	67

SA75-17-04	
Date	5/30/2017
Units	ng/L
PFOS	2.8 U
PFOA	1.2 J
PFOS+PFOA	1.2 J

SA75-17-03	
Date	5/30/2017
Units	ng/L
PFOS	6.9
PFOA	22
PFOS+PFOA	28.9

AOC 75
Building T-1445
Warehouse Fire

AOC 57 Area 1
(See Figure 4 - AOC 57 Area 1
Vertical Profiling and Soil Boring Locations)

75VP-1
75VP-2
75VP-3
75VP-4
75VP-5
75VP-6
75VP-7
75VP-8
75VP-9
SA75-17-01
SA75-17-02
SA75-17-03
SA75-17-04

Saratoga St
Grove Pond Rd

255
246
236
226

N
W
E
S

Legend

- Proposed Soil Boring and Vertical Profiling Location
- Proposed Vertical Profiling Location
- Proposed Soil Boring Location
- Groundwater Vertical Profiling Transects
- Temporary Well Location from SI
- Estimated Groundwater Flow Direction
- Area of Contamination (AOC)
- Topographic Contour (feet above sea level)
- Former Fort Devens Boundary

Note:
Topographic Contour Source: MassGIS, Elevation Contours (1:5,000) - North American Vertical Datum of 1988.

Bold/highlighted results exceed EPA LHA of 70 ng/L for separate or combined PFOS + PFOA.

AOC 75 Proposed Vertical Profiling and Soil Boring Locations
Devens PFAS RI - Area 1 FSP Addenda

Former Fort Devens Army Installation
Devens, Massachusetts

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0 100 200
Feet

Date: 05/25/2018

Figure 3

File: PFAS2018_RI_WP_AOC75_VPL_SB.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Proposed Soil Boring and Vertical Profiling Location
- Groundwater Vertical Profiling Transects
- Appoximate Groundwater Flow Direction
- Approximate Extent of Excavation (1994)
- Topographic Contour (feet above sea level)
- Stream
- Area of Contamination (AOC)
- Former Fort Devens Boundary

Note:

Topographic Contour Source: MassGIS, Elevation Contours (1:5,000) - North American Vertical Datum of 1988.

Aerial Sources: 2013, USGS, MassGIS

AOC 57 Area 1 Proposed Vertical Profiling and Soil Boring Locations
Devens PFAS RI - Area 1 FSP Addenda

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Devens, Massachusetts

KOMAN Government Solutions, LLC
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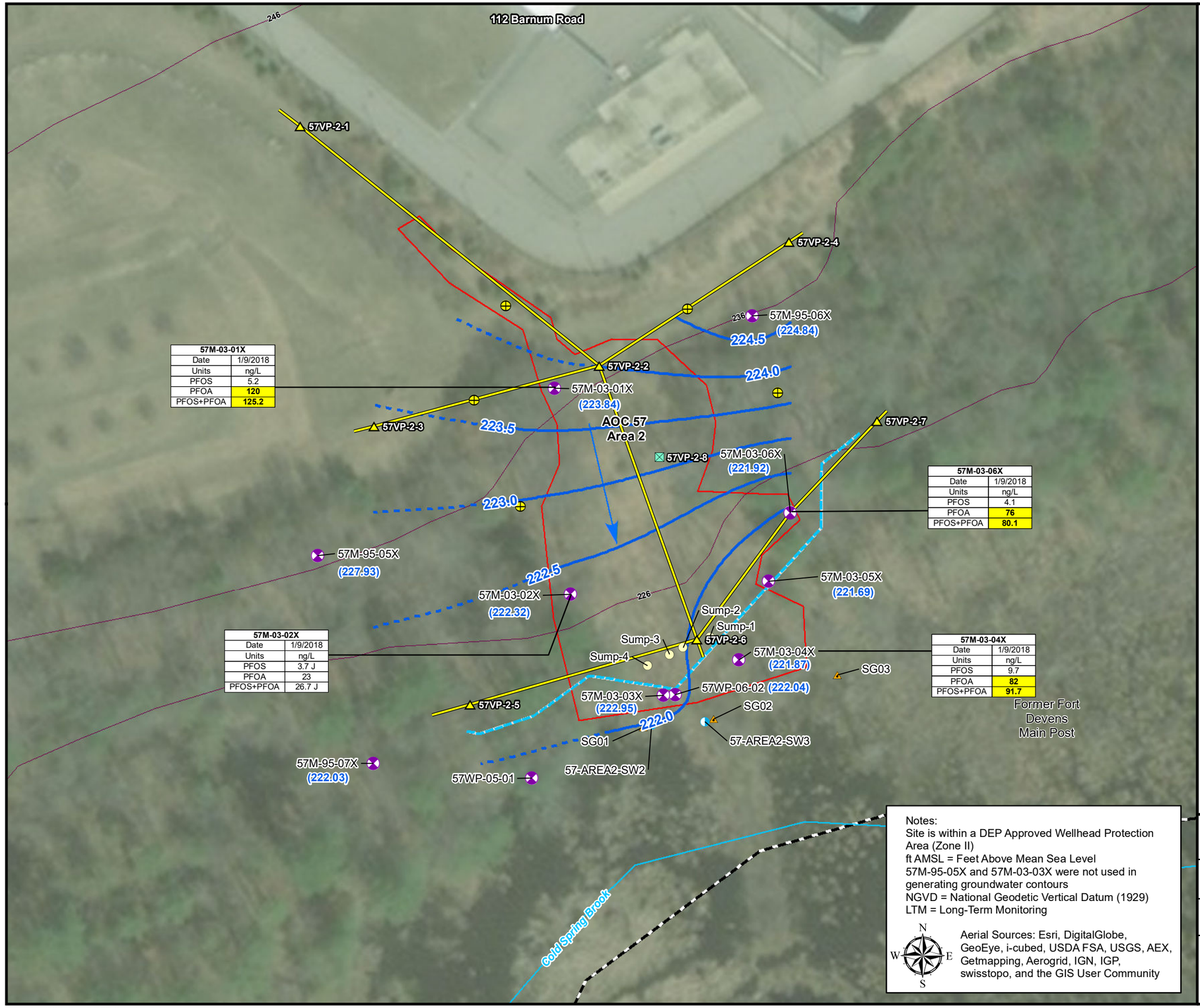
0 30 60
Feet

Date: 05/25/2018

Figure 4

File: PFAS2018_AOC57-1_VPL_SB.mxd



57M-03-01X	
Date	1/9/2018
Units	ng/L
PFOS	5.2
PFOA	**120**
PFOS+PFOA	**125.2**

57M-03-06X	
Date	1/9/2018
Units	ng/L
PFOS	4.1
PFOA	**76**
PFOS+PFOA	**80.1**

57M-03-02X	
Date	1/9/2018
Units	ng/L
PFOS	3.7 J
PFOA	23
PFOS+PFOA	26.7 J

57M-03-04X	
Date	1/9/2018
Units	ng/L
PFOS	9.7
PFOA	**82**
PFOS+PFOA	**91.7**

Legend

- Proposed Soil Boring and Vertical Profiling Location
- Proposed Vertical Profiling Location
- Proposed Soil Boring Location
- Groundwater Vertical Profiling Transects
- LTM Well
- Staff Gauge
- Former Surface Water Sample Location
- Sump
- (222.03) Groundwater Elevation (ft NGVD) (June 2017)
- Groundwater Elevation Contour (ft NGVD) (Contour Interval = 0.5 ft) (June 2017)
- Inferred Groundwater Elevation Contour
- Groundwater Flow Direction
- 57M-03-06X Well/Piezometer/Sump/Sample Location Identification
- Flagged Wetland Limits
- Stream
- Topographic Contour (feet above sea level)
- Area of Contamination (AOC)
- Former Fort Devens Boundary

Note:
Topographic Contour Source: MassGIS, Elevation Contours (1:5,000) - North American Vertical Datum of 1988.

Bold/highlighted results exceed EPA LHA of 70 ng/L for separate or combined PFOS + PFOA.

Notes:
Site is within a DEP Approved Wellhead Protection Area (Zone II)
ft AMSL = Feet Above Mean Sea Level
57M-95-05X and 57M-03-03X were not used in generating groundwater contours
NGVD = National Geodetic Vertical Datum (1929)
LTM = Long-Term Monitoring

Aerial Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

AOC 57 Area 2 Proposed Vertical Profiling and Soil Boring Locations
Devens PFAS RI - Area 1 FSP Addenda

Former Fort Devens Army Installation
Devens, Massachusetts

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0 30 60
Feet

Date: 05/25/2018

Figure 5

File: PFAS2018_AOC57-2_VPL_SB.mxd

Notes:
Site is within a DEP Approved Wellhead Protection Area (Zone II)
Well 57M-96-09X buried by construction.
ft AMSL = Feet Above Mean Sea Level
NGVD = National Geodetic Vertical Datum (1929)
LTM = Long-Term Monitoring

N W E S

Aerial Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

246
236
226

G3M-93-09X
57VP-3-3
57VP-3-2
57M-96-09X
AOC 57 Area 3
57VP-3-1
57VP-3-8
57M-95-03X
(224.13)
224.0
57VP-3-4
57M-96-10X
223.0
57VP-3-7
57M-96-12X
(222.93)
222.0
57VP-3-6
57WP-06-03
(222.11)
57M-96-11X
(221.45)
57M-96-13X
(222.91)
221.0
57P-98-03X
57VP-3-5
57P-98-04X
(220.10)
57-AREA3-SW1
Cold Spring Brook

57M-95-03X	
Date	1/10/2018
Units	ng/L
PFOS	20 U
PFOA	82
PFOS+PFOA	82

57M-96-11X	
Date	1/10/2018
Units	ng/L
PFOS	2.0 U
PFOA	5.2
PFOS+PFOA	5.2

Area 3 SW-1	
Date	1/10/2018
Units	ng/L
PFOS	0.59 J
PFOA	24
PFOS+PFOA	24.6 J

Legend

- Proposed Soil Boring and Vertical Profiling Location
- Proposed Vertical Profiling Location
- Proposed Soil Boring Location
- Groundwater Vertical Profiling Transects
- LTM Well
- Well Point
- LTM Piezometer
- Surface Water Sample Location
- Monitoring Well - Abandoned (2012)
- Monitoring Well - Destroyed
- (220.10) Groundwater Elevation (ft NGVD) (June 2017)
- Groundwater Elevation Contour (ft NGVD) (Contour Interval = 0.5 ft) (June 2017)
- Inferred Groundwater Elevation Contour
- Groundwater Flow Direction
- 57M-95-03X Well/Piezometer/Sample Location Identification
- Stream
- Topographic Contour (feet above sea level)
- Area of Contamination (AOC)/ 1999 Excavation Area
- Alternate III-2a Estimated Soil Excavation Area (approximate location)

Note:
Topographic Contour Source: MassGIS, Elevation Contours (1:5,000) - North American Vertical Datum of 1988.

Bold/highlighted results exceed EPA LHA of 70 ng/L for separate or combined PFOS + PFOA.

AOC 57 Area 3 Proposed Vertical Profiling and Soil Boring Locations
Devens PFAS RI - Area 1 FSP Addenda

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
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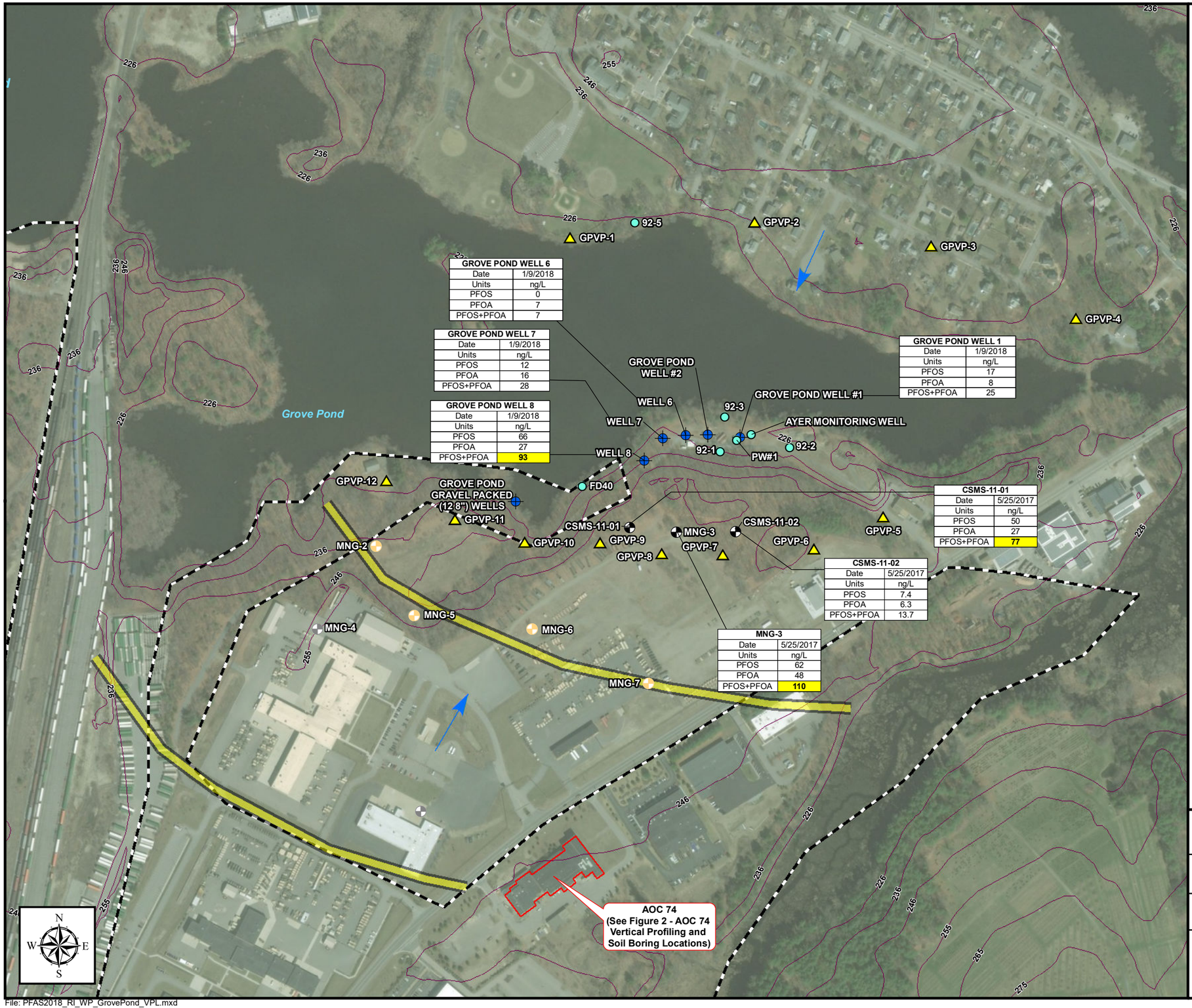
0 30 60
Feet

Date: 05/25/2018

Figure 6

KGS

File: PFAS2018_AOC57-3_VPL_SB.mxd



Legend

- Proposed Vertical Profiling Location
- Subsequent Groundwater Vertical Profiling Transects
- Monitoring Well
- Monitoring Well (Damaged)
- Monitoring Well (Destroyed)
- Public/Sentry Well
- Public Water Supply Well
- Approximate Groundwater Flow Direction
- Topographic Contour (feet above sea level)
- Area of Contamination (AOC)
- Former Fort Devens Boundary

Note:
Topographic Contour Source: MassGIS, Elevation Contours (1:5,000) - North American Vertical Datum of 1988.

Bold/highlighted results exceed EPA LHA of 70 ng/L for separate or combined PFOS + PFOA.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Grove Pond Wellfield Proposed Vertical Profiling Locations
Devens PFAS RI - Area 1 FSP Addenda

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
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0 200 400
Feet

Date: 05/25/2018

Figure 7

KGS

File: PFAS2018_RI_WP_GrovePond_VPL.mxd

change symbol to "Proposed Surface Water and Sediment Sampling Location"

Plow Shop Pond

Balch Pond

Grove Pond

Cold Spring Brook

Approximate Location of Well 8 Outfall

GPSW-5

GPSW-3

92-5

BPSW-1

GPSW-1

GPSW-2

GPSW-4

GROVE POND WELL 1

Date	1/9/2018
Units	ng/L
PFOS	17
PFOA	8
PFOS+PFOA	25

GROVE POND WELL 6

Date	1/9/2018
Units	ng/L
PFOS	0
PFOA	7
PFOS+PFOA	7

GROVE POND WELL 7

Date	1/9/2018
Units	ng/L
PFOS	12
PFOA	16
PFOS+PFOA	28

GROVE POND WELL 8

Date	1/9/2018
Units	ng/L
PFOS	66
PFOA	27
PFOS+PFOA	**93**

GROVE POND WELL #2

92-3

GROVE POND WELL #1

WELL 6

WELL 7

WELL 8

92-1

PW#1

92-2

AYER MONITORING WELL

FD40

GROVE POND GRAVEL PACKED (12 8") WELLS

CSMS-11-01

Date	5/25/2017
Units	ng/L
PFOS	50
PFOA	27
PFOS+PFOA	**77**

CSMS-11-02

Date	5/25/2017
Units	ng/L
PFOS	7.4
PFOA	6.3
PFOS+PFOA	13.7

MNG-2

MNG-3

MNG-4

MNG-5

MNG-6

MNG-7

MNG-1

MNG-3

Date	5/25/2017
Units	ng/L
PFOS	62
PFOA	48
PFOS+PFOA	**110**

CSBSW-6

AOC 74 Barnum Road Firefighting Exercise Area

SA74-17-02

Date	6/5/2017
Units	ng/L
PFOS	3.8
PFOA	**140**
PFOS+PFOA	**143.8**

SA74-17-03

Date	6/5/2017
Units	ng/L
PFOS	**130**
PFOA	**360**
PFOS+PFOA	**490**

SA74-17-01

Date	5/30/2017
Units	ng/L
PFOS	2.2 J
PFOA	37
PFOS+PFOA	39.2 J

SA74-17-04

Date	5/30/2017
Units	ng/L
PFOS	1.8 J
PFOA	3.9 J
PFOS+PFOA	5.7 J

SA74-17-05

Date	5/30/2017
Units	ng/L
PFOS	19
PFOA	29
PFOS+PFOA	48

57M-95-03X

Date	1/10/2018
Units	ng/L
PFOS	20 U
PFOA	**82**
PFOS+PFOA	**82**

AOC 75 Building T-1445 Warehouse Fire

AOC 57 Area 2

AOC 57 Area 3

AOC 57 Area 1

SA75-17-01

Date	6/5/2017
Units	ng/L
PFOS	3.5 J
PFOA	2.3 J
PFOS+PFOA	5.8 J

57M-03-01X

Date	1/9/2018
Units	ng/L
PFOS	5.2
PFOA	**120**
PFOS+PFOA	**125.2**

57M-96-11X

Date	1/10/2018
Units	ng/L
PFOS	2.0 U
PFOA	5.2
PFOS+PFOA	5.2

SA75-17-02

Date	6/5/2017
Units	ng/L
PFOS	49
PFOA	18
PFOS+PFOA	67

Area 3 SW-1

Date	1/10/2018
Units	ng/L
PFOS	0.59 J
PFOA	24
PFOS+PFOA	24.6 J

SA75-17-04

Date	5/30/2017
Units	ng/L
PFOS	2.8 U
PFOA	1.2 J
PFOS+PFOA	1.2 J

57M-03-06X

Date	1/9/2018
Units	ng/L
PFOS	4.1
PFOA	**76**
PFOS+PFOA	**80.1**

57M-03-02X

Date	1/9/2018
Units	ng/L
PFOS	3.7 J
PFOA	23
PFOS+PFOA	26.7 J

57M-03-04X

Date	1/9/2018
Units	ng/L
PFOS	9.7
PFOA	**82**
PFOS+PFOA	**91.7**

SA75-17-03

Date	5/30/2017
Units	ng/L
PFOS	6.9
PFOA	22
PFOS+PFOA	28.9

SA75-17-01

SA75-17-02

SA75-17-03

SA75-17-04

SA74-17-01

SA74-17-02

SA74-17-03

SA74-17-04

SA74-17-05

CSBSW-5

CSBSW-4

CSBSW-3

CSBSW-2

CSBSW-1

57M-95-03X

57WP-06-03

57M-96-10X

57M-96-11X

57M-96-12X

57M-96-13X

57P-98-03X

57M-03-01X

57M-95-06X

57M-03-02X

57M-95-05X

57M-03-06X

57M-03-05X

57M-03-03X

57M-03-04X

57WP-06-02

57M-95-07X

57WP-05-01

57-AREA3-SW1

57P-98-04X

Ga St

Pond Rd

N

W

E

S

Legend

- Proposed Surface Water and Sediment Sampling Location
- LTM Well
- LTM Well Point or Piezometer
- Surface Water Sample Location
- Monitoring Well
- Monitoring Well (Damaged)
- Monitoring Well (Destroyed)
- Public/Sentry Well
- Temporary Well Location from SI
- Public Water Supply Well
- Area of Contamination (AOC)
- Former Fort Devens Boundary

Note:
Topographic Contour Source: MassGIS, Elevation Contours (1:5,000) - North American Vertical Datum of 1988.

Bold/highlighted results exceed EPA LHA of 70 ng/L for separate or combined PFOS + PFOA.

Area 1 Proposed Surface Water and Sediment Sampling Locations
Devens PFAS RI - Area 1 FSP Addenda

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 300 600
Feet

Date: 05/25/2018

Figure 8

File: PFAS2018_RI_WP_PropSW_Sed_Area1.mxd

James Ropp

Subject: RE: Devens PFAS Area 1 sampling rationale

From: Chaffin, David (DEP) [mailto:david.chaffin@state.ma.us]
Sent: Wednesday, May 23, 2018 1:59 PM
To: Katherine Thomas <KThomas@Komangs.com>; Mark Applebee <MApplebee@Komangs.com>; Hilyard, Mark/MMR <Mark.Hilyard@CH2M.com>; James Ropp <jropp@Komangs.com>; Reddy, Penelope W CIV (US) (PENELOPE.W.REDDY@usace.army.mil) <PENELOPE.W.REDDY@usace.army.mil>; 'robert. j. simeone. civ' <robert.j.simeone.civ@mail.mil>; Groher, Daniel M CIV USARMY CENAE (US) (Daniel.M.Groher@usace.army.mil) <Daniel.M.Groher@usace.army.mil>; Kulbersh, Michael R CIV USARMY CENAE (US) (Michael.R.Kulbersh@usace.army.mil) <Michael.R.Kulbersh@usace.army.mil>; Carol Keating (keating.carol@epa.gov) <keating.carol@epa.gov>; Laurie Oconnor (Oconnor.Laurie@epa.gov) <Oconnor.Laurie@epa.gov>; Ron Ostrowski (ROstrowski@Massdevelopment.com) <ROstrowski@Massdevelopment.com>
Subject: [EXTERNAL] RE: Devens PFAS Area 1 sampling rationale

For Use In Intra-Agency Policy Deliberations

_____

This looks like a good program for Area 1 – for discussion tomorrow, a few comments and questions on the meeting materials:

1. Which PFAS analyte list will be used?

   Response: Analyte list specified by EPA Method 537 plus the 6:2 and 8:2 telemors.

2. Where is groundwater from Ayer well No. 8 being discharged to Grove Pond?

   As discussed during hr 24 May 2018 Planning Meeting, according to Mark Wetzel of the Town of Ayer Municipal Water Department, the effluent from Ayer Municipal Well #8 is being discharged to the pond shoreline between municipal well #7 and #8. Due to the location of the discharge (which contains PFAS greater than the LHA), the proposed surface water location GPSW-2 will be moved to the east, away from the discharge point for municipal well #8.

3. Table 2: The information that is not currently available for the wells listed under the Grove Pond Well Field heading should be obtained, and If possible, associated boring logs and well logs should be obtained. Simililarly, to the extent possible, construction data (e.g., screen depths and elevations, etc.), boring logs, and construction logs from all of the Ayer supply wells should be obtained.

   Noted. Historic reports are being reviewed in an effort to obtain well construction information. Information will be incorporated into Table 2 as it si obtained.

4. A vertical profile location should added upgradient of AOC 57 Area 1 (Figure 4) to assist with the determination of source location if PFAS is detected in the two proposed profile locations.

   The goal for the two borings proposed at AOC 57 Area 1 is to determine the presence or absence of PFAS in soil and or groundwater. If PFAS contamination in soil and/or groundwater is detected additional sampling will be completed.

5. Figure 7: Consider locating GPVP-2, GPVP-3, and GPVP-4 closer to the Grove Pond shoreline to screen the area between the proposed locations and the shoreline.

   The locations of these borings were chosen with consideration for rig access within public right of ways, rather than drilling on private residential property. Mark Wetzel from the Ayer Water Department indicated that a sewer right-of-way exists along the Grove Pond shoreline. It may be possible to access it with the direct-push rig. Team agreed to evaluate this right-of-way may be accessible to the rig and sufficient utility clearances can be achieved.

6. Figure 8: Surface water/sediment sample pairs collected downslope of AOC 57 Areas 1, 2, and 3 should be collected from wetland areas most likely to impacted by a release from each of the areas, rather than the main channel of Cold Spring Brook. If significant impacts are revealed, the downstream impacts to the brook can be assessed subsequently.

   Agreed. The surface water/sediment sample locations will be at locations will be in wetlands adjacent to the bank, rather than in the main brook channel, which can ne distant from the upland bank.

David Chaffin
Massachusetts Department of Environmental Protection
One Winter Street, Boston, MA 02108
617-348-4005
Follow MassDEP on Twitter: twitter.com/MassDEP
Visit our web site: mass.gov/dep

-----Original Appointment-----
From: Katherine Thomas [mailto:KThomas@Komangs.com]
Sent: Tuesday, May 15, 2018 4:25 PM
To: Mark Applebee; Hilyard, Mark/MMR (Mark.Hilyard@CH2M.com); James Ropp; Reddy, Penelope W CIV (US) (PENELOPE.W.REDDY@usace.army.mil); 'robert. j. simeone. civ'; Groher, Daniel M CIV USARMY CENAE (US) (Daniel.M.Groher@usace.army.mil); Kulbersh, Michael R CIV USARMY CENAE (US) (Michael.R.Kulbersh@usace.army.mil); Carol Keating (keating.carol@epa.gov); Laurie Oconnor (Oconnor.Laurie@epa.gov); Chaffin, David (DEP); Ron Ostrowski (ROstrowski@Massdevelopment.com)
Subject: Devens PFAS Area 1 sampling rationale
When: Thursday, May 24, 2018 9:00 AM-11:00 AM (UTC-05:00) Eastern Time (US & Canada).
Where: https://zoom.us/j/744963712

Hi Team,

We would like to conduct this meeting using Zoom. This will allow us to share our computer screen and make comments on figures that all attendees can see in real time. A link to the meeting via Zoom is provided below. There is also a phone number below that you can use to dial into the meeting if necessary. Attached are meeting materials (text and tables) and figures that we plan on discussing during the meeting. Please review the materials before the meeting. We will us your comments and discussion from the meeting to make revisions to the Area 1 sampling rationale that will be incorporated into the Area 1 FSP.

Hi there,

MA Conference Room is inviting you to a scheduled Zoom meeting.

Join from PC, Mac, Linux, iOS or Android: https://zoom.us/j/744963712

Or iPhone one-tap :
US: +16699006833,,744963712# or +19294362866,,744963712#
Or Telephone:
Dial(for higher quality, dial a number based on your current location):
US: +1 669 900 6833 or +1 929 436 2866
Meeting ID: 744 963 712
International numbers available: https://zoom.us/u/c1pIfeIZ3

<< File: Area 1 FSP figures.pdf >> << File: Area 1 FSP meeting materials.pdf >>